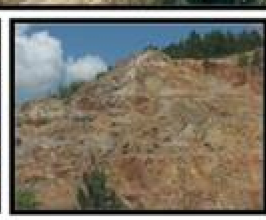
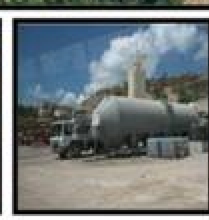
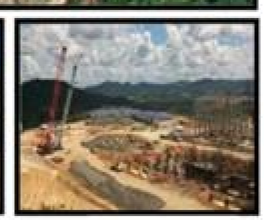
Volume II Appendices

EIA Technical Review Guidelines: Non-Metal and Metal Mining

Regional Document prepared under the CAFTA DR Environmental Cooperation Program to Strengthen Environmental Impact Assessment (EIA) Review







Prepared by CAFTA DR and US Country EIA and Mining Experts with support from:

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EIA Technical Review Guidelines: Non-Metal and Metal Mining

Volume II

The EIA Technical Review Guidelines for Non-Metal and Metal Mining were developed as part of a regional collaboration to better ensure proposed mining projects undergoing review by government officials, non-governmental organizations and the general public successfully identify, avoid, prevent and/or mitigate potential adverse impacts and enhance potential beneficial impacts throughout the life of the projects. The guidelines are part of a broader program to strengthen environmental impact assessment (EIA) review under environmental cooperation agreements associated with the "CAFTA-DR" free trade agreement between the United States and five countries in Central America and the Dominican Republic.

The guidelines and example terms of reference were prepared by regional experts from the CAFTA-DR countries and the United States in both the government organizations responsible for the environment and mining and leading academics designated by the respective Ministers supported by the U.S. Agency for International Development (U.S. AID) contract for the Environment and Labor Excellence Program and grant with the Central America Commission for Environment and Development (CCAD). The guidelines draw upon existing materials from within and outside these countries and from international organizations and do not represent the policies, practices or requirements of any one country or organization.

The guidelines are available in English and Spanish on the international websites of the U.S. Environmental Protection Agency (U.S. EPA), the International Network for Environmental Compliance and Enforcement (INECE), and the Central American Commission on Environment and Development (CCAD): www.epa.gov/oita/ www.inece.org/ www.sica.int/ccad/ Volume 1 contains the guidelines with a glossary and references which track with internationally recognized elements of environmental impact assessment; Volume 2 contains Appendices with detailed information on mining, requirements and standards, predictive tools, and international codes; and Volume 1, part 2 contains example Terms of Reference cross-linked to Volumes 1 and 2 for exploration and exploitation for non-metal and metal mining projects respectively for use by the countries as they prepare their own EIA program requirements.

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APPENDIX A. WHAT IS MINING?

1 INTRODUCTION

There are several steps or phases in a successful mining operation:

Extraction is the first phase of hardrock mining which consists of the initial removal of ore either by open pit or underground.

Beneficiation is the next step, and the initial attempt at liberating and concentrating the valuable mineral from the extracted ore. Depending on the grade of the ore removed from the mine, ore may be initially crushed, then either processed further by concentration through heap leaching or other methods. Beneficiation employs one or more methods to separate material into two or more constituents, at least one of which is the desired product. These methods are used to prepare ores for further intensive processing and use the differences between the physical properties of the various minerals in the ore to concentrate the target mineral.

Following beneficiation, the valuable minerals can be further concentrated through a variety of pyrometalurgical or hydrometallurgical processes. Pyrometalurgical processes involve placing ore concentrates in smelters where they are melted to create a final metal product. Most new metal facilities are no longer using smelters and are relying on hydrometallurgical processes (the best known is cyanide tank leach with electrowinning followed by melt furnaces).

Hydrometalurgical processes take an ore concentrate and combine it with a wide variety of chemicals to form a metal rich solution, which is then solvent-extracted and electrowinned into a final metal. The mineral may be extracted by dissolution in large tanks and then recovered by chemical processes.

Gold may be recovered from ore by heap leaching, performed by stacking the ore and applying cyanide solutions directly through a sprinkler or drip type system. The solutions then percolate through the ore, dissolving the metals. The metal-laden (pregnant) solution is collected at the base of the pile (heap) and pumped to a processing plant where the metal is recovered from the liquid. Many new gold mines no longer use heap leaching and are designed to concentrate the gold out of the ore by leaching the ore within tanks. This design is more environmentally sound than heap leaching.

2 EXTRACTION METHODS

There are two basic ways in which minerals are mined (extracted) – surface or open pit mining and underground mining. The choice of an extractive method depends on the local topography; depth and type of mineral being mined; the shape, size and location of the ore body; and cost considerations. Solution mining (in-situ leaching) is a specialized, less common process used on certain types of metal and sulfide ore deposits.

2.1 SURFACE OR OPEN-PIT

A surface mine generally consists of a large open-pit dug into the earth or along the side of hill or mountain with very high pit walls. This kind of mine is the least expensive kind, and is every miner's first choice where an ore body is situated close to surface, is big enough, and has little overburden. Open-pit mines look simple, but every pit needs to be tailor made. First and foremost, the pit walls have to be stable and stay up, so it is important to understand the rock-mechanics of the pit walls to determine a safe slope for the pit. There is also a delicate balance between how much overburden and waste rock can be mined in order to gain access to the valuable ore and how deep a pit can be.

An open-pit mine is constructed in a series of benches, decreasing in size from the surface to the bottom of the mine. The size and location of the first bench of any open pit mine is critical. It is excavated well into the rock surrounding an ore body. Since each successive bench is smaller than the one that was removed above it, the depth to which the pit can be mined is determined by the size and location of the first cut or bench.

Surface mining requires the removal and disposal of a layer of soil and rock containing no minerals, commonly called the overburden. A second layer of rock, known as waste rock, containing low concentrations of ore is also removed and, depending on the ore content, is either processed or disposed. The ratio between the tonnage of waste to ore is known as the stripping ratio. The lower this ratio the less waste rock that has to be removed and the lower the operating costs.

After the overburden and waste rock are removed to expose the ore body, ore is drilled, blasted, loaded into trucks and hauled to the appropriate facility for disposal, beneficiation, or processing. Once the high-quality deposit is exposed, excavation continues, with further disposal of surrounding low-grade waste rock, until the valuable body of ore has been removed. After initial crushing and grinding, the high-quality ore is then transported to the mill for further processing. Lower grade ore may be transported to a heap leach pad where a solution is applied to release the mineral from the rock.

The main cost advantage of open pit mining versus underground is that the miners can use large and more powerful shovels and trucks, because the equipment is not restricted by the size of the opening it must work in. This allows faster production, and the lower cost also permits lower grades of ore to be mined.

If an ore body is large, and extends from surface to great depth, it is common to start mining near the surface from an open pit. This provides some early revenue while preparations are made for underground mining of the deeper parts of the ore body. It is not uncommon for ore below the floor of an open pit to be developed from underground by driving a ramp (adit) from the lower part of the pit.

2.2 UNDERGROUND

Underground mining methods are used when mineralized rock occurs deep beneath the earth's surface. To reach the ore body, remove ore and waste, and provide ventilation, miners must excavate either a vertical shaft, a horizontal adit, or an inclined passageway. Within the ore deposit, horizontal passages call drifts and crosscuts are developed on several levels to access mining areas called stopes. Blasted rock is hauled away by trains, loaders, or trucks that may bring it directly to the surface or transport it to a shaft where it is hoisted to the surface and sent to a crushing facility.

There are three basic types of underground mining methods, the selection of which is dependent on the shape of the ore body. These methods are:

Stoping - These underground operations involve sinking a vertical shaft or driving a horizontal adit, both of which provide access to the ore body. This type of extraction technique is best adapted to steeply dipping vein-type deposits.

Room-and-pillar mining - In this process, ore is mined in two phases, the first phase involves driving large horizontal drifts (called rooms) parallel to each other and smaller drifts perpendicular to the rooms. Once the mine reaches the end of the ore body, the second phase of operations may begin to recover the ore left behind in the pillars between the smaller, perpendicular drifts. These operations are best for deposits that are horizontal.

Block caving - The block-caving method of mine development utilizes the natural forces of gravity to cause the ore to break on its own accord without being drilled and blasted. A typical block-caving mine is developed by first driving a series of parallel haulage drifts below the ore body. From the haulage drifts, a series of holes are driven up into the ore body at a 45-degree angle. The holes are drilled in sufficient quantity until the structure of the drilled portion of the ore body is weakened enough so that gravity causes it to fall into the underlying drifts. The ore is collected from the drifts and removed using loaders.

Generally, ore bodies are either vein type, massive or tabular in shape. This together with ore thickness and regularity will influence the mining method selected.

- Vein type ore bodies usually dip steeply, allowing ore to fall to a lower mining level where it can be loaded. The ore bodies are usually narrow and often irregular, so care must be taken to avoid mining barren wall rock. They are most successfully mined by small-scale underground stoping.
- Massive ore bodies are large and usually have an irregular shape. Underground bulk mining methods, with large stopes, are best suited to this type of ore body.
- Tabular ore bodies are flat or gently dipping and the ore, having nowhere to fall, must be handled where it is blasted. Room and pillar mining is normally used to extract the ore. Depending on the thickness and lateral extent of the ore, these types of deposits tend to be moderate-to high tonnage producers.

The strength of the ore and the rocks surrounding an ore body also influence the method. Openings may be supported or self-supported. Some supported openings are held up by backfill, waste rock or aggregate placed in the openings shortly after they are mined out. In the past, miners often supported walls and ceilings in underground mines (“workings”) with “sets” made of timber or steel. This kind of mining, however, is costly and is little used today. To support open workings in modern mines, it is more usual to inset steel rock bolts, to use bolt to secure a network of steel straps or screens, or to apply quick-setting concrete to the back and sides of openings.

If walls and pillars are of sufficient strength to carry both the weight of rock above them and the horizontal stresses in the rock caused by tectonic forces, workings can be self-supporting, although the miner may add strength and stability with rock bolts and screens. In massive ore bodies, it is common to plan for the mining of pillars. This is done by backfilling the mined out stopes to provide the necessary support when pillars are mined.

2.3 SOLUTION MINING

Solution mining or in situ leaching is an alternative to the underground and surface techniques described above. Its use for the mining of metal oxide and sulfide ores has increased since 1975. Solution mining involves drilling and pumping a dilute sulfuric acid or other reagent solution directly into the below ground ore body. The reagent dissolves the metals in the ore and the solution is collected by various means such as wells or sumps. It is then pumped to the surface and recovered using electrical/chemical techniques.

Solution mining has enabled facilities to beneficiate lower-grade sulfide and oxide ores. Solution mining presents unique environmental challenges since it requires constant management of solutions deep underground.

3 BENEFICIATION

Mined ore, with a few exceptions, must be beneficiated before further processing. Beneficiation, commonly referred to as milling, is the processing of ores to regulate the size of a desired product, remove unwanted constituents, and/or improve the quality, purity or assay grade of a desired product. Processing methods range from simple crushing, washing, screening and drying, to highly complex methods used to process copper, lead, zinc, silver, and gold ores.

3.1 MILLING

The first step in beneficiation is milling. Typically, this is accomplished by a series of size reduction operations – commonly referred to as crushing and grinding. Crushing is the first step in the process. It is performed on the mined ore and may be done in two or three stages. Primary crushing systems consist of crushers, feeders, dust control systems, and conveyors used to transport ore to coarse ore storage. Size separators (such as screens and griddles) control the size of the feed material between the crushing and grinding stages. Griddles are typically used for very coarse material. Screens mechanically separate ore sizes using a slotted or mesh surface that acts as a "go/no go" gauge. Vibrating and shaker screens are commonly used as separators.

After the crushing, the ore is ground. Grinding is the last stage in milling. Most facilities use a combination of rod and ball mills to grind ore. Depending on the particular process being used at the mine, the crushed ore may be ground as a slurry or as a dry material. Ground material is also screened to achieve the desired size and uniformity, usually between 20 and 200 mesh. After the final screening, if the ore has been ground as a dry material, water is added to the form a slurry.

3.2 AMALGAMATION

Gold and some other precious metals will amalgamate when brought into contact with metallic mercury – meaning that the liquid mercury will alloy with the surface gold to form a mercury-coated particle which has surface properties similar to those of pure mercury. The amalgamated particles will coalesce and cling together, similar to drops of pure mercury, and will collect into a single puddle. When mercury has amalgamated as much gold as possible, a gray plastic mass will form. Heating this mass distills off the mercury leaving behind metallic gold. This method exposes both the workers and the environment to mercury and is viewed as not a state-of-the-art approach to mining gold. The only use of mercury currently is limited to very small scale commercial or artisanal gold mining.

3.3 FLOTATION

Metals can also be concentrated through flotation, a method of mineral separation in which a number of reagents selectively float or sink finely crushed minerals in an enclosed floatation cell. These separation techniques use physical and chemical properties of the target minerals along with process chemicals to separate relatively pure minerals from remaining wastes. The wastes are then discarded along with the liquids used in the process. The solid mine waste from flotation are discarded as mine tailings in a pond or impoundment. Tailings often contain a wide range of metals not recovered in the ore concentrate. The disposal of tailings may pose specific environmental challenges since tailings may leach metals into the environment or due to the sulfide content of tailings, they may generate acid rock drainage which accelerates the leaching of metals from the tailings.

3.4 LEACHING

Some ores are more amenable to be leached to recover low concentrations of metals. Many copper and gold mines use forms of leaching. All leaching methods involve percolating a solution or reagent .

There are four main types of leaching: dump, heap, vat, and in situ (discussed above under Solution Mining). In each type, the basic components of the process are deposits of low grade ore, a leaching solution, and a holding/recovery area used to extract the desired metal from the solution. The leaching process chosen depends on the concentration of metals in the ore and economics of the mining operation. For instance, dump leaching is often used on copper ore with 0.05 percent of more copper content, while heap leaching is used for higher grade ores with copper concentrations between 0.5 and 1.0 percent. Gold mining uses both heap leaching and vat leaching.

Dump leaching is a widely used leaching process in copper mining, and may cause the most environmental damage. This process involves the dumping of ore into large piles (dumps) of crushed and uncrushed low grade ore that cannot be profitably processed through other methods. These leach dumps often reach heights of up to 60 meters and can contain several million metric tons of rock. Precipitation and additional acidic leach solution is used to dissolve the desired minerals into solution. The leaching solution is sprayed, injected, and/or washed over the dump pile, and solution is collected in ditches that drain to ponds.

Heap leaching is a modified form of dump leaching often conducted on a smaller scale and with higher-grade ore. The ore is usually crushed and placed on a specially prepared pad made of synthetic material, asphalt, or compacted clay. Reagents are used as the leaching solution, typically composed of strong acids or bases for base metals or cyanide for precious metals.

Vat leaching treats the highest grade ore of any leaching process and involves placing crushed ore into an enclosed vat of reagents (rather than percolating the reagent solution through the ore).

In all leaching processes, the desired metals must be recovered from the leaching solution. The leaching solution containing dissolved metals is pumped from a holding pond (or from holding tanks) to a removal plant. Metals are recovered from the solution using chemical or electrical processes. Once the metal has been removed from the leach solution, the solution is typically reconstituted and used again in the leaching process.

3.5 OTHER PROCESSING

Metals exist in nature as either sulfide or oxide compounds. These compounds must be reduced to extract metal. This reduction can be carried out through either electrolytic or chemical processes, or a combination of both. Chemical reduction includes reductive smelting and autoclave hydrogen reduction. Electrolytic reduction (electrowinning) consists of simply passing a current through a dissolved or molten metal oxide to produce the neutral metal. Before reduction, it is often necessary to separate the metal compounds from the raw ore.

Separation can be done using froth flotation, gravity concentration, electrostatic separation, or magnetic separation. Froth flotation uses various reagents to separate particles. Hydrophobic particles are recovered in the froth and hydrophilic particles are discharged into the tailings. Different kinds of ores use different kinds of reagents. Oxide ores can be separated using oxalic acid whereas sulfide ores are recovered using xanthate or dithiophosphate type collectors. Because the specific gravity of most metals is higher than the sounding rock, metals can also be separated using shaking tables, centrifugal concentrators, or other methods which depend on gravity for separation. Electrostatic and magnetic concentrators use the electric or magnetic properties of the particles to separate the metals.

Electrowinning is another process that can then be used to reduce metals. In this process, a current is passed from an inert anode through a liquid leach solution containing the metal so that the metal is extracted as it is deposited in an electroplating process onto the cathode. Chemical reduction can be carried out in a variety of processes, including reductive smelting- the process of heating an ore with a reducing agent (often coke or charcoal) and agents to separate the pure molten metal from the waste products. Some other processes for chemical reduction include autoclave hydrogen reduction and converting.

4 WASTE

In the extraction and beneficiation processes there are several waste products. These are described as follows:

4.1 WASTE GEOLOGICAL MATERIAL

Mining operations generate two types of waste, overburden/waste rock and mine development rock. Overburden/waste rock results from the development of surface mines, while mine development rock is a byproduct of mineral extraction in underground mines. The quantity and composition of waste varies greatly between sites, but these wastes will contain minerals associated with both the ore and host rock. Overburden/waste rock is usually disposed of in unlined piles, while mine development rock may be used on-site for road or other construction (if it is found not to leach metals). Mine development rock may also be stored in unlined on-site piles or in underground openings (if it also is found not to leach metals to the environment). Waste piles may be referred to as mine rock dumps or waste rock dumps.

The location and design of the dumps need to be controlled and protected from erosion and sedimentation. Runoff and leachate from waste rock dumps may contain heavy metals, and these piles may generate acid drainage if sufficient amounts of sulfide minerals and moisture are present. The generation of acid drainage is one of the most significant environmental challenges in modern mining.

4.2 MINE WATER

Mine water includes all water that collects in surface or underground mines from groundwater seepage or inflow from surface water or precipitation. While a mine is operational, excess water must be pumped out to keep the mine dry and allow access to the ore body. There are two ways for controlling mine water: pumping from ground water wells to lower the water table or pumping directly from the mine workings. The recovered water may be used in beneficiation and dust control, pumped to tailings or mine water ponds, or discharged to surface water (if it meets discharge standards).

The composition and quantity of mine water varies among mining sites due to local conditions and the type of strata and ore. The chemical composition of mine water depends on the geochemistry of the ore body and the surrounding area. Mine water may also be contaminated with small quantities of oil and grease from mining equipment and nitrates from blasting operations. After a mine is abandoned, pumping is usually stopped, allowing the pit or workings to fill with water if the mine is below the pre-mining water table. Through aeration and contact with sulfide minerals, the accumulated water can acidify and become contaminated with heavy metals, as well as dissolved and suspended solids. Even in non-acidic waters, metals and metalloids such as antimony, arsenic, mercury, and others can be released depending of the pH condition of the water. Over time, this may lead to uncontrolled releases of mine water to surface waters and groundwater, as well as result in the formation of post-mining pit lakes that pose risks to waterfowl and other biological resources.

4.3 CONCENTRATION WASTES

Beneficiation operations used to concentrate mineral ores generate various types of wastes. Flotation systems discharge tailings consisting of liquids and solids. The solids include mostly rock material of little value and small amounts of unrecovered accessory minerals. The liquid component consists of water, dissolved solids, and reagents not consumed during flotation. The reagents may include cyanide, which is used as a depressant in certain flotation operations. Flotation wastes are generally sent to lined tailings ponds, in which solids settle out. The clarified liquid may be recycled to the mill or discharged, provided it meets water quality standards. The characteristics of flotation tailings vary considerably, depending on the ore, reagents, and processes used. Other types of beneficiation wastes include waste slurries from milling and gravity concentration steps.

The proper design, operation and closure of tailings ponds present another environmental management challenge. The water that accumulates in tailings ponds contains many pollutants and can be extremely toxic to wildlife. Many mines are no longer using wet deposition of tailings and now dispose tailings using a “dry” disposal where most of the water is removed from the tailings and the tails are then placed on the ground, rolled and compressed and stacked. Such a disposal option effectively eliminates long term water management issues related to traditional wet deposition.

4.4 MINERAL PROCESSING WASTES

Wastes from traditional smelting operations include various forms of slag, air pollution control dusts, furnace brick and a range of smaller quantity hazardous waste liquids. Most slag contains higher concentrations of metals but they are mostly bound in the slag. Some slags may be reused for construction purposes. Smelter air pollution dusts are often very high in metals content and in some circumstances can be placed back through the smelter with the ore concentrate. Metals emitted to the air from smelters, if not properly controlled, can cause serious environmental damage to human health and the environment through air, water, and soil pathways.

Wastes from hydrometallurgical operations include spent solvents from the solvent extraction portion of the process. In some cases spent solvent is blended with clean solvent and reused in the process. Some spent solvent is routinely removed and disposed of to maintain the quality of the solvent. The electrowinning tanks also generate spent electrolyte which like solvent can be reused if mixed with new fresh electrolytes. Some electrolyte is also disposed. Electrowinning also generates tank slimes which in the case of copper may contain precious metals. In that case slimes and sludges are collected and shipped offsite for precious metals recovery. Other forms of electrowinning generate slimes or sludges that must be disposed.

Many hydrometallurgical waste streams may be hazardous and must be handled and properly treated and disposed of. Ancillary hazardous wastes may be generated at on-site laboratories and include chemicals, liquid samples, and ceramics/crucibles which are disposed of off-site at commercial hazardous waste facilities. Other hazardous wastes may include spent paints and solvents generated from facility maintenance operations, spent batteries, asbestos, and polychlorinated biphenyls (PCBs) from electrical transformers. Waste oil also may be generated, and might be hazardous. Non-hazardous wastes are likely to include sanitary wastewater, power plant wastes and refuse.

APPENDIX B. MINING IN CAFTA-DR COUNTRIES

This paper presents a brief overview of mineral extraction in CAFTA-DR countries. It is divided into three sections. The first sections present a general comparison in terms of mineral production in the countries. The second section is a brief overview of mineral extraction in each of the 6 countries. The final section contains a list of references used in this report.

1 REGIONAL OVERVIEW

The mineral extraction industries of CAFTA-DR produce a variety of metals and industrial minerals. In the metals mining sector, antimony, gold, iron ore, lead, silver, nickel and zinc are being produced. Industrial production includes clays, gypsum, limestone, marble, pozzolan, pumice, salt and common sand and gravel (Anderson, 2008, Bermúdez-Lugo, 2008). Table C-1 presents a country-by-country comparison of the minerals extracted in the CAFTA-DR region.

In the metals mining sector, there are relatively few large active mines (Table C-2). These mines are either underground or surface/open pits mines. Most active mines are milling and extracting the metals on-site with a marked increase in production of gold, and to a lesser extent silver, between 2002 and 2006 in the CAFTA-DR region (see Figure B-1).

Current investment in the region's metals mining sector is mainly focused on discovering and developing gold deposits that lie mostly along the Central American Gold Belt (CAGB). The CAGB extends southeastward from western Guatemala (the Marlin deposit) across Guatemala (the Cerro Blanco deposit), through central El Salvador, southern Honduras, Nicaragua, and into western Costa Rica (the Crucitas deposit) (Anderson, 2008). Exploration also dominates the metals mining sector activities in the Dominican Republic. Figure B-2 presents a bar chart and table based on the Mines and Quarry Database of current exploration activities by country for various metal commodities.

As for industrial minerals, crushed stone, limestone, and other aggregates dominate mineral production in each of the CAFTA-DR countries. Mining of these minerals normally takes place in quarries (similar to open-pit mines) and in some cases in dredging operations. At this time, little information is publically available to indicate the exact nature of the quarrying operations or the number of operations per country. Based on USGS Minerals Yearbook 2006, regional trends for the various industrial minerals are variable as illustrated in Figures B-3 and B-4; however, general production rates for limestone and sand/gravel operations have remained relatively steady, at least between 2002 and 2006. In contrast, there has been a steady production increase for clays and gypsum and a decrease in salt production, with lime remaining quite constant in the CAFTA-DR countries.

Table B- 1: Extractive Mineral Industries in CAFTA-DR Countries (Anderson, 2008 and Bermúdez-Lugo, 2008)

Country	Costa Rica	Dominican Republic	El Salvador	Guatemala	Honduras	Nicaragua
Industrial Minerals						
Bauxite		X				
Barite				X		
Coal				X		
Amber		X				
Clay	X			X	X	X
Diatomite	X					
Gypsum				X	X	X
Lignite		X				
Lime	X	X		X		X
Limestone	X	X	X		X	X
Marble				X	X	
Pectolite (larimar)		X				
Phosphatic			X			
Pumice (pozzolan)	X		X	X		X
Salt (Marine)	X		X	X		X
Silica Sand	X			X		
Sand and Gravel	X	X		X	X	X
Metals						
Iron ore				X	X	
Copper					X	
Cadmium					X	
Nickel		X				
Gold			X	X	X	X
Lead					X	
Nickel		X				
Silver			X	X		
Zinc				X		
Molybdenum		X				
Other Minerals	X	X	X	X	X	X

Table B- 2: Number and Types of Metal Mines in CAFTA-DR Countries (Source: Mqdata.com)

Commodity	Costa Rica	Dominican Republic	Guatemala	Honduras	Nicaragua
Antimony			1 S		
Copper				1 S	
Gold	1 S/U 1 U		2 S/U	3 S	2 S/U 1 S
Lead				1 U	
Molybdenum		1 S			
Nickel		1 S	1 S		
Silver	1 S/U			1 U	
Zinc				1 U	

U = Underground S = Surface/Open pit S/U = Open pit and underground

Figure B- 1: CAFTA-DR Region Gold and Silver Production Trends (Anderson, 2008 and Bermúdez-Lugo, 2008)

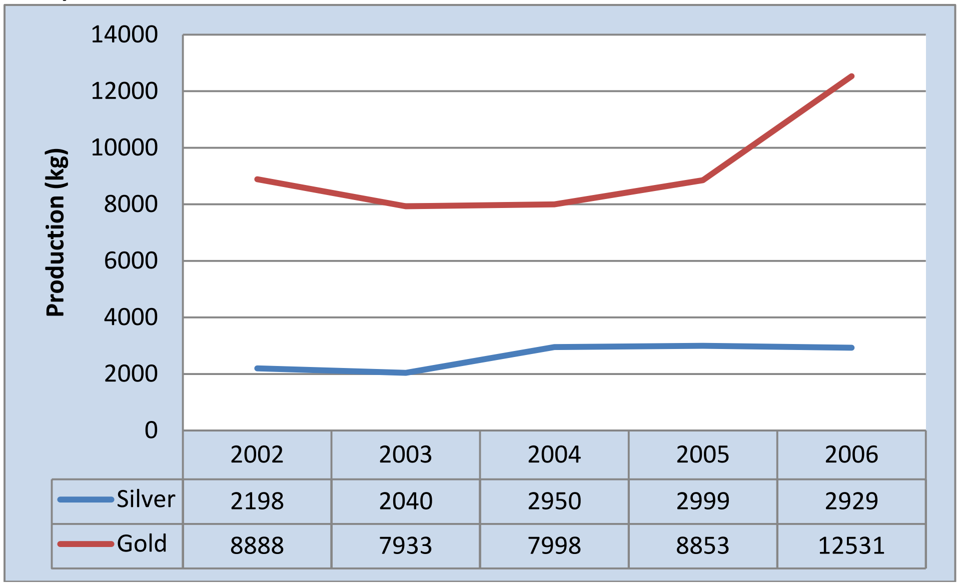


Figure B- 2: CAFTA-DR Region Metal Exploration Projects (Anderson, 2008 and Bermúdez-Lugo, 2008)

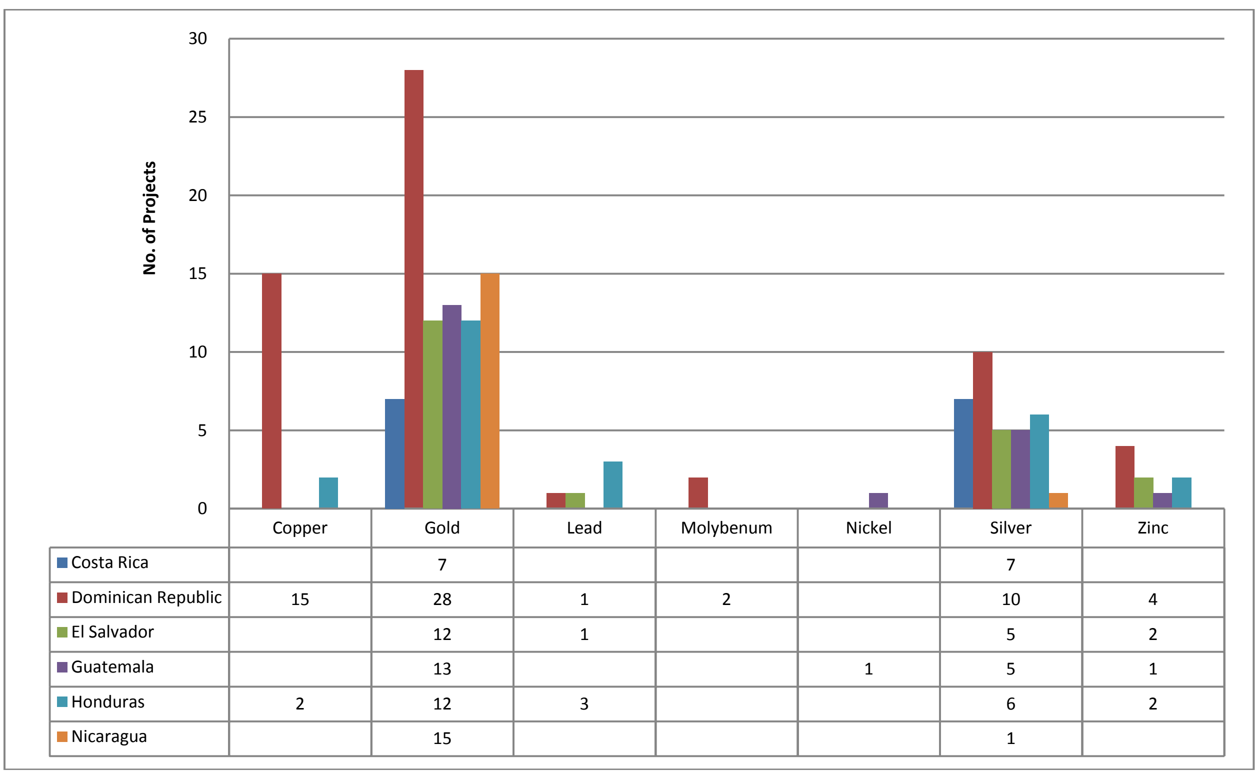
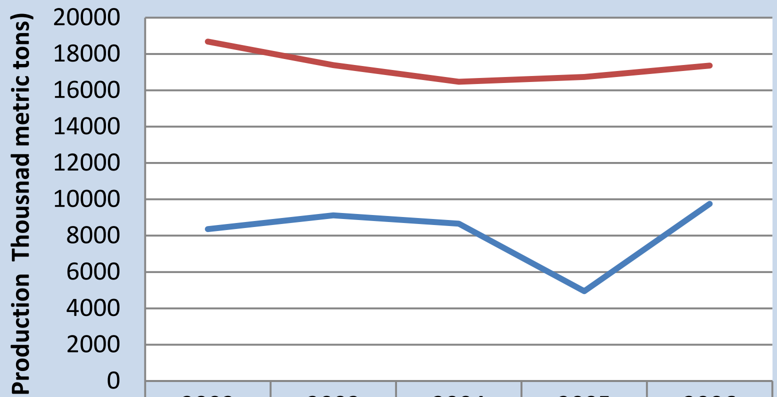
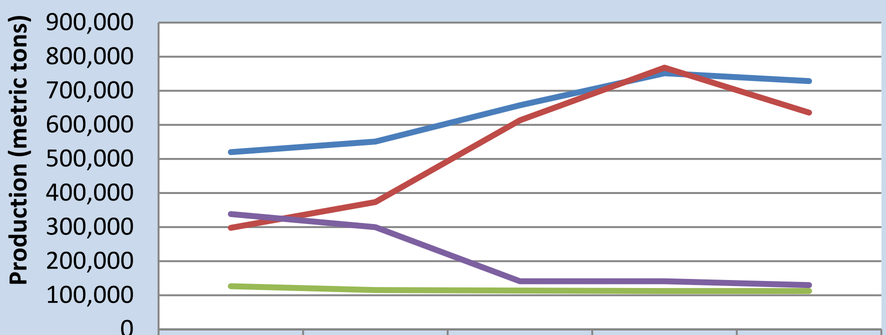


Figure B- 3: CAFTA-DR Region - Limestone and Sand/Gravel Production Trends (Anderson, 2008 and Bermúdez-Lugo, 2008



	2002	2003	2004	2005	2006
Limestone and Dolomite	8360	9121	8659	4942	9754
Sand and Gravel	18684	17392	16473	16734	17361

Figure B- 4: CAFTA-DR Region – Industrial Mineral Production Trends (Anderson, 2008 and Bermúdez-Lugo, 2008



	2002	2003	2004	2005	2006
Clays	519,882	550,821	657,652	751,558	728,448
Gysum	297779	373449	613287	767899	635832
Lime	126898	115234	113882	112578	112751
Salt	338540	299674	141400	141400	130000

The significance of each of these extracted minerals to the economies of each CAFTA country is a matter of debate. As presented in Table B-3, the mineral extraction industries contribute from less than 1 percent to 3 percent of the gross national product (GNP) of these countries. However, most mineral production is for industrial materials used for domestic purposes, and their contribution to GNP, may not be fully reflected in these values. Similarly, income from small local operations may not be captured in the national accounts.

Table B- 3: CAFTA-DR Regional Mineral Production Information

Country	Costa Rica	Dominican Republic	El Salvador	Guatemala	Honduras	Nicaragua
Industrial Minerals, Type of Mineral as Percentage of Total.						
Bauxite		3% (2005)				
Diatomite	0.41% (2006)					
Gypsum		2% (2005)		2.45% (2006)	0.18% (2006)	0.48% (2006)
Limestone	15% (2006)	8% (2005)	94% (2006)	52.26% (2006)		3.57% (2006)
Marble			2% (2006)	0.54% (2006)	53.4% (2006)	
Salt	0.03% (2006)	1% (2005)	0.24% (2006)	0.54% (2006)		0.34% (2006)
Sand and Gravel	78% (2006)	85% (2005)	NA	18.36% (2006)	44.5% (2006)	95.46% (2006)
Clay	7% (2006)	1% (2005)		2.44% (2006)	0.62% (2006)	0.03% (2006)
Pumice (pozzolan)	0.13% (2006)		<0.01% (2006)	4.82% (2006)		0.1% (2006)
Phosphatic			5% (2006)			
Lime	0.17% (2006)	4% (2005)				0.3% (2006)
Metals, Description of Operations						
Antimony				1% of world's supply in 2006		
Gold	Gold production is currently from small operators with uncertain production	GlobeStar Mining Corporation ore to smelters with gold as by product	No major mines are currently operating – small mines do exist	Gold is extracted from two operating mines. Refining method unknown	Three operating gold mines using heap leach	Three major gold mines in the country
Silver		GlobeStar Mining Corporation ore to smelters with silver as by product	No major mines are currently operating – small mines do exist)		One silver mine	
Copper Ore		Ore to smelters with recovery of up to 90%				
Lead Ore						
Nickel		Leading export. 3rd leading industry globally		3rd largest producer in Latin America		
Zinc		GlobeStar Mining Corporation ore to smelters with recovery of up to 85%				
Iron Ore					0.76% (2006)	
GPA percentage of Total GPA	0.2% in 2006	2% in 1988 7.8% in 2008(?)	1% in 1999	3% in 2006	2% in 2006	1% in 2006

*Percentages are based on reported data in the USGS Minerals Yearbook 2006 (Anderson, 2008).

Finally, in each of the CAFTA-DR countries, the affect of mineral extraction on the environment is very much of a concern. Concerns include water consumption; water pollution from increase sedimentation, toxic spills and failures of heap leach and tailings dams; air pollution from dust and other substances; and deforestation. Table B-4 presents a brief overview of the principle concerns in each country.

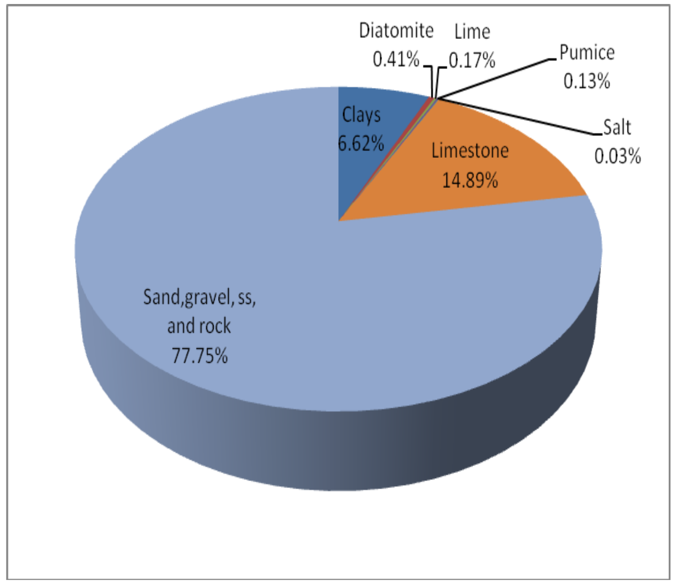
Table B- 4: CAFTA-DR Region - Environmental Concerns Due to Mining

Environmental Concerns	Costa Rica	Dominican Republic	El Salvador	Guatemala	Honduras	Nicaragua
Water shortages	X	X	X	X	X	X
Contamination of water	X	X	X	X	X	X
Health issues	X	X	X	X	X	X
Air pollution (dust, hydrogen cyanide and sulfur dioxide)	X	X	X	X	X	X
Contamination of soil	X	X		X	X	X
Increased deforestation	X	X	X	X	X	X
Damage to ecosystems and farmland	X	X		X	X	X
Effects of hurricanes on impacts from mining activities	X	X		X	X	X

2 CAFTA-DR COUNTRY OVERVIEWS

2.1 COSTA RICA

Figure B-5: Costa Rica Minerals Production (Anderson, 2008)



According the USGS *2006 – Minerals Yearbook* (Anderson, 2008),mineral production made up approximately 0.2% of Costa Rica's total Gross Domestic Product in 2006. Figure C-5 illustrates mineral production in Costa Rica. Sand, gravel, rock and limestone quarrying dominate this sector. Diatomite, approximately 0.41% of domestic mineral production, is estimated to account for approximately 1% of world diatomite production (U.S. Energy Information Administration, 2007; Founie, 2008; Seaward and Coates, 2008; Banco Central de Costa Rica, undated).

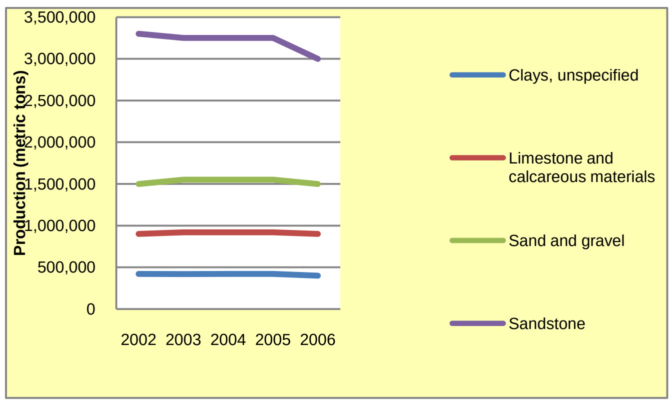
In May of 2002, a moratorium was placed on the development on the opening of any new open pit mines, and any commercial-scale cyanide processing (Executive Decree Nº 30477-MINAE). The moratorium was repealed with issuance of Executive Decree 34492-MINAE of 18 March 2008, which promulgated the Environmental Safeguard for Mining in Costa Rica, a set of basic guidelines that must be followed in both metallic and non-metallic mining to ensure sustainability and environmental protection (Global Legal Information Network, 2008). Promulgation of the Decree was largely brought about by the failure of a heap leach facility at the Bellavista Mine.

Table B-5 presents production estimates for various extracted mineral commodities, not including manufactured commodities such as cement and petroleum products. Gold production sharply rose in 2006 with the opening of the Bellavista mine; however, the mine's temporary closure in 2007 has resulted in decreased gold production. On May 11, 2010 Decree No. 35 982-published by MINAET declared a national moratorium for an indefinite period for gold metal mining activity in the country as the exploration, exploitation, and the beneficiation of the materials extracted used cyanide or mercury.

Table B-5: Costa Rica 2002 - 2006 Mineral Production (Anderson, 2008)

Extracted Mineral	Production (metric tons except where noted)				
	2002	2003	2004	2005	2006
Clays, unspecified	420,000	419,000	420,000	420,000	400,000
Diatomite	26,400	26,450	26,500	26,000	25,000
Gold (kilograms)	100	110	150	424	1,210
Lime	10,000	10,000	10,000	10,000	10,000
Pumice	8,000	8,000	8,000	8,000	8,000
Salt, marine	20,000	20,000	20,000	20,000	20,000
Crushed rock and rough stone	200,000	200,000	200,000	200,000	200,000
Limestone and calcareous materials	900,000	920,000	920,000	920,000	900,000
Sand and gravel	1,500,000	1,550,000	1,550,000	1,550,000	1,500,000
Sandstone	3,300,000	3,250,000	3,250,000	3,250,000	3,000,000

Figure B-6: Costa Rica Mineral Extraction Trends



According to Hellman & Schofield Pty. Limited (2008), other production of gold comes from small scale gold miners and some other relatively small projects such as the Beta Vargas mine, which is located near La Pita de Chomes, Puntareanas. The San Juan of Abangares-Guanacaste Mine which was put into production by Lyon Lake Limited in the 1990's and reportedly extracted 60,000 ounces of gold. In addition, small scale gold panning in rivers is reported in various areas of Costa Rica (Hellman & Schofield Pty. Limited, 2008). The main area known to have more continuous activity of this kind is the South Pacific Coast, near Panama. Underground gold mining also occurs in the area of Abangares.

As for other mineral commodities, trends as illustrated in Figure B-6 indicate that production between 2002 and 2006 have remained rather constant. Production of these materials is for domestic use and varies according to economic conditions.

2.1.1. Future Development

With the exception of gold, mineral production in Costa Rica will most likely continue at the same rate as in the past depending on economic conditions. The 2002 moratorium on open pit mining and Executive Decree 34492-MINAE have created uncertainty regarding future gold mining in Costa Rica. Once environmental issues are resolved, Glencairn Gold Corporation hopes to have Bellavista mine back in production. However, the Crucitas Project, located in northern Costa Rica and owned by Infinito Gold Ltd., is currently the only major exploration project in the country. According to Infinito Gold Ltd. (2008) the concession area is around 800 km^2 and has 1,200,000 indicated oz Au @ 1.32 g/t. In the early

2000's the EIA for this project was rejected; however, Infinito (2008) now claims to have amended the EIA and received the hard rock mining environmental permit. They have a $US 600,000 environmental bond and will pay for periodic independent environmental audits. It is uncertain whether there are any new developments planned for other commodities.

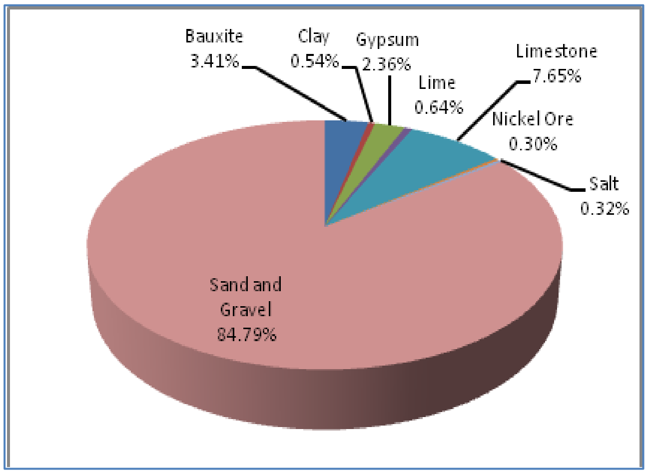
2.1.2.Environmental Concerns

Concerns regarding water quality impacts, potential hazards of cyanide, deforestation, and socio-economic impacts led to the moratorium on open-pit mining and commercial scale cyanide leaching. According to Earthworks (2007), groups were critical of the Environmental Management Plan for the Bellavista mine for failing to adequately address environmental and social concerns. The failure of the heap leach pad at Bellavista has resulted in more scrutiny on the gold mining industry in Costa Rica.

As for other commodities such as limestone, sand and gravel, and quarried rock, the concerns focus on deforestation, increased sedimentation due to erosion, and air pollution due to dust are among the main concerns. At one silica sand quarry operated by SICORSA near Cartago in Central Costa Rica, steps are being taken to put waste material into beneficial use by using the clay rich tailings for brick clay. Such reuse of waste material could have a beneficial impact on the environmental and the economy (Mitchell et al, undated).

2.2 DOMINICAN REPUBLIC

Figure B-7: Dominican Republic – 2005 Non-metallic Mineral Production (Bermúdez-Lugo, 2008)



The Dominican Republic produces bauxite, cement, ferronickel, gypsum, limestone, marble, nickel, salt, sand and gravel, and steel (Figure B-7). Limestone, marble, and sand and gravel are produced solely for domestic consumption. Amber and pectolite (larimar) are also produced in modest amounts by artisanal miners (Bermúdez-Lugo, 2008). Mineral production has stagnated since the mid-1980s. In 2000, mining accounted for 2% of GDP. While GDP has grown by 7.8% since 2000, mining production has increased by 9.2% stimulated by higher output and a higher average price of nickel, the country's most important mineral. Ferronickel is the country's leading export commodity and third-leading industry (Nations Encyclopedia, undated).

As in some other countries in CAFTA-DR, aside from sand and gravel, limestone extraction makes up the bulk of the minerals produced. In 2002, nickel production was 38,859 metric tons, ranking tenth in production in the world. In 2006, nickel ore production was around 46,526 metric tons down from the previous year's 53,124 metric tons. The only nickel producer was Falconbridge Dominicana, an 85% Canadian-owned company. In addition, the country is one of the few sources of amber in the Western Hemisphere. Salt Mountain, a 16 km block of almost solid salt west of Barahona, is the world's largest known salt deposit. There are also large deposits of gypsum near Salt Mountain, making the Dominican Republic one of three sources of gypsum in the Caribbean. Between 2002 and 2006, gypsum production has increased from 163,026 metric tons to 459,496 metric tons. Table B-6 presents recent mineral production rates in Dominican Republic.

Production of gold and silver in Dominican Republic was suspended in 1999. In 1980, the Pueblo Viejo gold mine was the largest in the Western Hemisphere. As production of gold and silver declined by the mid-1980s, mining of the sulfide zone of the gold ore body commenced, requiring more extensive processing facilities than had previously existed. Production of gold was 7,651 kg in 1987 and 3,659 kg in 1996. Production of silver was 39,595 kg in 1988 and 17,017 kg in 1996. Corporación Minera Dominicana started production in August 2008 of the Greenfield Cerro de Maimon polymetallic deposit, which is located in the municipality of Maimon in the Nouel Province about 70 km northwest of Santo Domingo (Redwood, 2009).

Production of bauxite, traditionally the principal mining product of the Dominican Republic, ceased in 1992 and rapidly increased again between the years 2003 and 2005. The Aluminum Company of America (Alcoa) mined bauxite between 1959 and 1983, when it turned its concession over to the state. In 1991, production dropped 92% from the previous year due to a presidential decree suspending mining operations at the largest bauxite mine. Since 2005, Sierra Bauxita Dominican SA has been mining bauxite from the Las Mercedes bauxite mine but halted operations in 2008 due to export license issues with the government (Redwood, 2009).

Table B-6 Dominican Republic Mineral Production - 2002-2006 (in metric tons unless noted) (Bermúdez-Lugo, 2008)

Extracted Mineral	Production (metric tons unless noted)				
	2002	2003	2004	2005	2006
Bauxite	--	6,481	79,498	534,555	NA
Clay	314	41,894	84,730	85,000	85,000
Gypsum	163,026	250,286	459,496	370,143	355,641
Lime	113,000	102,000	100,000	100,000	100,000
Limestone	1,115,000	1,607,000	1,214,000	1,200,000	1,200,000
Marble (cubic meters)	6,333	8,186	10,384	6,060	6,000
Nickel Mine output, laterite ore	38,859	45,253	46,000	53,124	46,526
Salt	207,278	156,988	50,000*	50,000*	50,000*
Sand and gravel	15,977,000	14,374,000	13,266,000	13,300,000	13,300,000

*does not include rock salt

2.2.1. Future Development

There are approximately 75 exploration activities for copper, gold, lead, molybdenum, nickel, silver and zinc taking place in the country (Mine and Quarry Data). Exploration projects are primarily being undertaken by Energold Mining Ltd., Everton Resources Inc., and Globestar. Exploration for metals is very active in the Dominican Republic. It is uncertain as to what development plans there are for other mineral commodities.

2.2.2.Environmental Concerns

The general environmental risks due to mining operations are well known in the Dominican Republic, especially due to the high potential of hurricanes, as described in Table B-7 below (United Nations Environmental Program/Office of Coordination of Humanitarian Affairs, 2007).

Table B-7: Potential Risks from Mining Properties due to Accidents aggravated by Flooding caused by Hurricanes - Dominican Republic

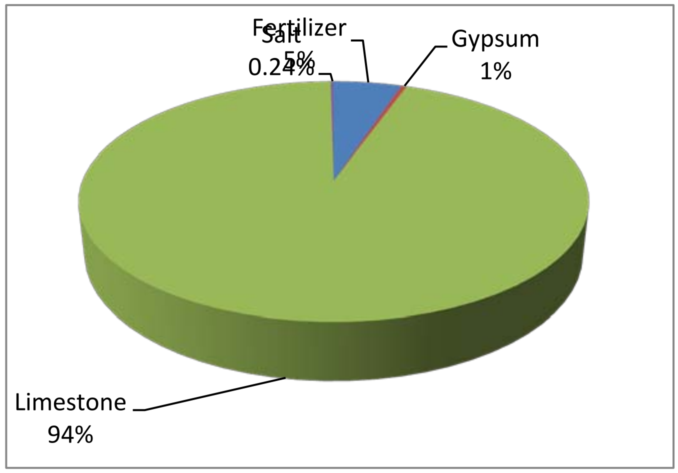
Possible type of incident	Typical cause of accidents possibly aggravated by the floods	Potential effects
Tailings dam failure	Poor water management, overtopping, foundation failure, drainage failure, piping, erosion, earthquake	Loss of life, contamination of water supplies, destruction of aquatic habitat and loss of crops and contamination of farmland, threat to protected habitat and biodiversity, and loss of livelihood
Failure of waste rock dump	Instability often related to presence of water (springs, poor dump drainage)	Loss of life, injuries, destruction of property, damage to ecosystems and farmland
Pipeline failure, e.g. tailings, leach solution	Inadequate maintenance, failure of equipment, physical damage to pipeline	Contamination of soil, water, effects on water users. May not be detected for some time.
Transport of chemicals to/from site	Inadequate transport procedures and equipment, unsafe packaging, high risk transportation routes	Contamination of soil, water, effects on water users, aquatic ecosystem damage, threat to human health
Ground Subsidence	Slope failure, breakthrough to surface	Loss of life, damage to property
Spills of chemicals at site, e.g. fuel tank rupture, reagent loss, storage damage	Poor maintenance, inadequate containment	Contamination of soil and water. Air pollution could have health effects
Fire	Poor design, unsafe practices in relation to flammable materials	Effects of air pollution on health, property damage
Atmospheric releases (dust, hazardous substances, etc.)	Inadequate design, failure to follow procedures, inadequate maintenance	Community concern, possible health effects
Explosions (plant)	Blasting and explosives accidents, poor practices, unsafe storage and handling	Community concern, loss of life, destruction of property, risk to life

Source: UNEP/OCHA, 200

2.3 EL SALVADOR

El Salvador's economy is largely based on agrarian production and exports with mineral production accounting for about 1% of its estimated gross domestic product (GDP) (Doan, 1999). Extractive mineral production in El Salvador mainly consists of limestone, pumice (pozzolan), and salt (marine). Limestone accounts for 47% of mineral production at approximately 1.2 million metric tons per year (Table C2-4 and Figure B-8). Currently, there are no large scale gold or silver mines operating in El Salvador, although small operations are known to exist. The location, production, and status of these mines are not known at this time.

Figure B-8: El Salvador- 2006 Non-metallic Mineral Production (Anderson, 2008)



2.3.1.Future Development

Mining of limestone and other commodities based on USGS data presented in Table 1 remained fairly constant between 2002 and 2006. At this time, more recent data are not available, but it is most likely that mining of these commodities will continue at current rates. In terms of gold and silver, there are 24 gold mining projects awaiting approval by the El Salvadorian government. Historically, mining has taken place in El Salvador but civil strife between the Government and the Frente Farabundo Marti de Liberacion Nacional (FMLN) discouraged exploration and mining operations throughout the 1980's. This continued until 1992, when a peace agreement was made (Doan, 2000). In the mid- to late 1990's, exploration and mining for these commodities began to return, especially in the northern half of the country where there were several prospects, particularly in the Departments of La Union, Morazan and San Miguel where epithermal quartz veins intersect older volcanic rocks (Doan, 2000). Numerous companies are undertaking gold and silver exploration in El Salvador. Two mines have been the focus of these activities: the historic El Dorado gold mine near San Isidro, located about 50 km east-northeast of San Salvador and the old San Sebastian gold mine near Santa Rosa de Lima.

Table B-8: El Salvador Mineral Production 2002-2006 (Anderson, 2008)

Extracted Mineral	Production (metric tons unless otherwise noted)				
	2002	2003	2004	2005	2006
Fertilizer materials					
Phosphatic	13,600	13,600	13,600	13,600	10,000
Other mixed materials	56,500	56,000	56,000	56,000	55,000
Gypsum	5,600	5,600	5,600	5,600	5,500
Limestone	1,631,000	1,194,000	1,161,000	1,150,000	1,200,000
Pozzolan (cubic meters)	279,389	294,871	222,826	223,000	223,000
Salt, marine	31,552	31,366	31,400	31,400	30,000

The El Dorado project is currently being operated by Pacific Rim Mining Company. According to Pacific Rim Mining (2008), gold was discovered in the district in the early 1500's, and small-scale production took place until the late 1800's. The New York and El Salvador Mining Company (a subsidiary of Rosario Mining) operated an underground mine on the El Dorado property from 1948 to 1953. During this time period, the mine used a simple mill and cyanide recovery system on approximately 270,000 tonnes of ore to yield about 72,500 troy ounces (2,250 kilograms) of gold at an average grade of 9.7 g/t from workings centered on the Minita vein system. Between 1993 and 2002, new exploration in the project area took place.

Currently, exploration activities are still on-going and the El Dorado project is awaiting a mining license from the El Salvador government. This project has been the center of considerable controversy from both an environmental/social/economic and legal standpoint. Local resistance has effectively shut the operation down and has prevented the government from issuing the necessary mining permits. The Pacific Rim under CAFTA has filed a Notice of Intent to file arbitration under CAFTA for $77 million of indirect appropriation. The 90-day resolution period ended on March 9, just days before El Salvador's presidential elections on March 15, 2009 (Dyer, 2009).

Historically, mining activity occurred near the old San Sebastian gold mine where mercury was used for amalgamation recovery of gold from gangue. At San Sebastian, the Commerce/Sanseb joint venture concentrated on developing an open pit mine over previous workings centered on the main gold zone. In 1987 Commerce/Sanseb was granted the 304-acre San Sebastian Gold Mine (SSGM) exploitation concession by the El Salvadoran Department of Hydrocarbons and Mines. This concession was renewed on May 20, 2004. On March 3, 2003, Commerce received the New San Sebastian Exploration License, and the company commenced exploring targeted areas in this 41-square km area (10,374 acres), which includes three formerly-operated mines and encompasses the SSGM. In September, 2006, the El Salvador Ministry of the Environment delivered to Commerce its revocation of the environmental permits issued for the SSGM exploitation concession. In December, 2006, Commerce filed with the El Salvadoran Court of Administrative Litigation of the Supreme Court of Justice two complaints relating to this matter. These legal proceedings are pending (Commerce Group Corp., 2008).

2.3.2.Environmental Concerns

Although there have been no major environmental catastrophes in El Salvador, environmental concerns have been the main justification for revocation or suspension of permits by the El Salvadoran government recently. A new draft mining law is being debated to address these issues, and the 24 gold and silver mining licenses have been suspended until the new law becomes effective. Environmental concerns include:

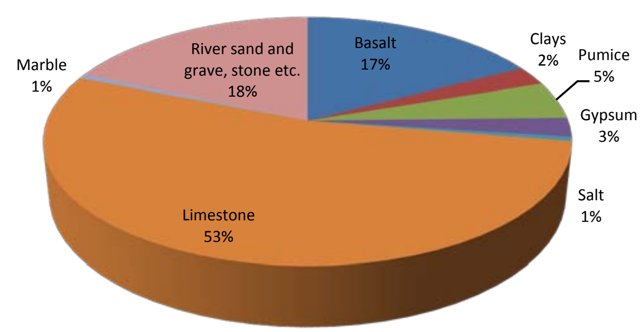
- Water shortages: El Salvador has chronic water shortages. It is estimated that 200,000 liters of water per day will be needed for new gold and silver mining activities with El Dorado alone requiring up to 30,000 liters/day for the mineral extraction process . This shortage is a point of contention.
- Increased deforestation: In 2005, the United Nations Development Program ranked El Salvador as the most highly deforested country in the world. Open pit and/or underground mining could add to this problem.
- Water pollution: Most mining activities will occur in the Lempa River basin. Not only does the Lempa River provide water to the northern region of El Salvador, but it also supplies an estimated 30% of the drinking water to the capital city. Mining, if not properly done, could contaminate these water supplies.

- Health issues: Mineral extraction has the potential to pollute air with dust, hydrogen cyanide, and sulfur dioxide.

Review of the literature as well internet searches indicates that current mining operations for limestone and other commodities are not as much of a environmental concern to residents as gold and silver mining operations. However, many of the same environmental impacts can occur during these types of operation as with large scale gold and silver mining. These include deforestation, water pollution from sediment produced from erosion and air pollution from dust. It is anticipated that the new mining law will also address these issues.

2.4 GUATEMALA

Figure B-9: Guatemala - 2006 Non-metallic Mineral Production (Anderson 2008)



According the US State Department (2008), mining has historically been a sensitive issue in Guatemala and operations have been subject to protests. Subsurface minerals and petroleum are the property of the state. Contracts for development are typically granted through production-sharing agreements. Complex and confusing laws and regulations, inconsistent judicial decisions, and bureaucratic impediments continue to constitute practical barriers to investment. The principal commercial minerals that have been mined in Guatemala are antimony, gold, iron ore, nickel, marble and lead. The production of antimony is estimated to be the only mineral mined in Guatemala to be of global significance (USGS, 2008).

The mining industry accounted for about 3% of the country's GDP at current prices (Anderson, 2008). Antimony production, which historically has been very important to Guatemala, fell from 4,010 tons in 2002 to 1,007 tons in 2005 (Anderson, 2008.). In 1997 Guatemala ranked third in Latin America for production, behind Bolivia and Mexico (Nations Encyclopedia, undated). No antimony production information is available for 2006, and it is not clear whether antimony production ceased or was temporarily suspended in the country, or production data were simply not available (Anderson, 2008). Gold was mined from the colonial period until the early 20th century and was a major export item. In 2006, gold production was about 5036 kg compared to 4,500 kg in 2001 (Anderson, 2008). Rough marble from the Huehuetenago District has been exported to Mexico and other nearby countries. Large nickel deposits in the Lake Izabal area have been developed. The Buena Vista nickel mine is currently operating. Barite, bentonite, kaolin, other clays, feldspar, gypsum, iron ore, lime, pumice, salt, limestone, sand and gravel, silica sand and other mineral commodities are also produced, primarily for domestic use (Nations Encyclopedia, undated.)

Table B-9 presents a summary of mineral production between the years 2002 and 2006 (Anderson, 2008). This table does not include manufactured commodities such as cement, steel, or petroleum products. The data indicate as shown in Figure B-9 that limestone (53.42%), sand and gravel (18.41%), and basalt (17.3%), used for domestic construction, make up the majority of the non-metallic minerals produced in Guatemala.

Table B-9: Guatemala Extracted Mineral Production 2002-2006 (Anderson, 2008)

Commodity	Production (in metric tons unless noted)				
	2002	2003	2004	2005	2006
Antimony	4,010	3,000	2,686	1,007	--
Basalt including andesite	318,000	936,000	1,050,000	1,000	1,604,000
Barite	100	100	70	181	--
Clays:					
Bentonite	12,415	6,438	81,688	135,451	20,034
Ferruginous, including shale	84,000	65,000	54,000	90,000	202,000
Fuller's earth (attapulgite)	10	9	9	--	19
Kaolin	372	1,497	--	4,107	4,395
Coal, lignite	--	--	50	--	--
Feldspar	11,843	9,320	4,473	3,808	17,176
Gold, mine output, Au content (kg)	--	--	--	741	5,036
Gypsum, crude	81,000	67,000	106,000	350,000	227,000
Hematite	947	1,000	2,689	5,227	--
Iron oxide, gross weight	35,226	2,276	2,823	11,268	7,341
Jadeite	92	48	27	27	419
Lead Run of mine,	39	19	47	23	28
Lime, hydrated	547	386	400	400	400
Magnesite	3,758	8,022	8,000	5,636	1,084
Pumice	377,000	274,000	226,000	82,000	447,000
Pyrolusite, manganese dioxide	--	--	5	--	--
Rhyolite	1,000	1,000	1,375	2,707	236
Salt	50,000	60,000	60,000	60,000	50,000
Silver, mine output, Ag content (kg)	--	--	--	7,074	49,719
Stone, sand, and gravel:					
Dolomite	24,881	6,130	63,082	8,585	2,333
Flagstone, phyllite (cubic meters)	98	59	1,446	513	18
Gravel, unspecified (cubic	69,918	166,851	19,678	60,116	120,109
Limestone, crude	3,040,000	3,773,000	4,270,000	140,000	4,938,000
Marble:					
Block (cubic meters)	3,185	7,461	33	--	--
Unspecified, including pieces	99,293	29,181	74,862	44,598	49,673
River sand and gravel	743,000	296,000	90,000	367,000	502,000
Sand, common	55,000	129,000	226,000	82,000	447,000
Sandstone (cubic meters)	200	450	180	--	--
Schist, slate	496,000	497,000	543,000	--	582,000
Silica sand	37,552	30,462	988	474	57,692
Stone dust (cubic meters)	7,433	12,537	1,852	--	44,307
Stone, round, unworked (cubic	10,088	48,894	10,000	5,799	69,114
Volcanic ash and sand (cubic	313,000	199,000	220,000	49,000	417,000
Talc and steatite	568	1,585	2,863	1,631	526
Zinc, run of mine,	--	--	10	11	--

Metals such as gold and silver are primarily produced by two mines: the El Sastre Mine, and the Marlin Mine. The El Sastre property is located at UTM coordinates 790,500 E and 1,638,000 N, and has an area of 271 ha. It lies south of the Motagua-Polochic Fault System that marks the northern boundary of the Chortis Block (a division of the Caribbean Plate). The rocks within the property are mainly amphibolite schists that are considered to be of phiolitic origin. The rocks appear to have been affected by low-angle thrusts that control the mineralization (Olson et al, 2007). The property is owned 50% by Castle Gold Corporation and 50% by Aurogin Resources Ltd, both of Canada. The El Sastre Main zone is a high-grade, near-surface oxide gold deposit. Construction of a heap leach gold operation at the site was completed along with the mine's first gold pour in late 2006. Gold production was 13,819 ounces in 2007 and was expected to be 12, 000 ounces in 2008 (Castle Gold Corporation, 2008).

2.4.1.Future Development

Several off shore companies are currently conducting exploration on about 160 concessions provided by the Guatemalan government. These companies are:

1. Castle Gold Corporation/Aurugin is primarily interested in gold and silver in concessions near their existing El Sastre Mine;
2. Firestone Ventures is mainly prospecting for zinc, lead, and silver in the Huehuetenango area of northwestern Guatemala;
3. Hudbay Minerals, now joined with Skye Resources registered under Compañía Guatemalteca de Níquel, S.A., is looking to reopen the Fenix Nickel Mine near El Estor, Izabal, aswell as explore concessions known as Niquegua in an area covering 384.4 km^2 in the municipalities of El Estor, Panzós and Cahabón. 30% of the joint venture is owned by the government of Guatemala (MAC, 2009);
4. BHP Billiton, formally Jaguar Nickel (registered as Minera Mayamérica, S.A), is primarily exploring for nickel near Buena Vista, and also in El Estor, Izabal, Panzós and Cahbón in the department of Alta Verapaz (MAC, 2009);
5. Radius Exploration Ltd (registered as Exploraciones Mineras de Guatemala, S.A and Exmingua, S.A) is primarily exploring for gold.
6. Goldex Resources is exploring for gold in the El Plato District.
7. Goldcorp Inc. is exploring for gold near their existing Marlin mine on concessions granted for their Cerro Blanco Projects and Holly/Banderas Property.

It is uncertain as to development plans for other extracted minerals.

2.4.2.Environmental Concerns

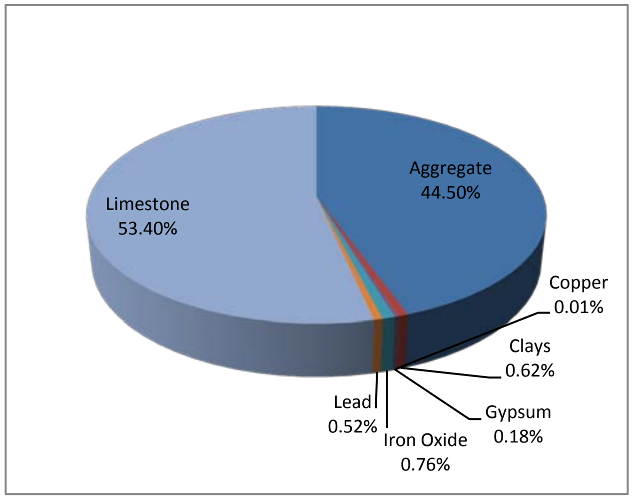
As in other Central American countries, there is much concern in Guatemala about the affects of mining on the environment. Concerns include the potential for deforestation and habitat loss or degradation, loss of agricultural land and the associated traditional livelihoods, release of cyanide and other hazardous chemicals, erosion and sedimentation, water pollution, dust and air pollution, and other factors. Earthquakes and hurricanes are common occurrences in Guatemala, and their impacts are of serious concern. Major earthquakes and floods caused by hurricanes can result in failures of heap leach pads, tailings dams, and pipelines; hazardous chemical accidents, and landslides.

Guatemalan Congressional Law Decree Number 48-97, signed into law on 11 June 1997, declared that the “technical and rational exploitation of hydrocarbons, minerals and other non-renewable natural resources is in the public interest, entrusting to the State to sponsor the necessary conditions for their exploration and exploitation.” The interpretation of this law and the Law for Protection and Improvement of the Environment by the Government of Guatemala prohibits the emission and discharge of polluting matter or agents that may affect the environment. These laws and interpretation have been a matter of contention for environmental non-governmental organizations (NGOs) and indigenous peoples. Their concerns are both socio-economic and environmental in nature. Protests against mining projects have lead to confrontations between protestors, mining companies and the government. There are concerns that some mining leases on native lands are in direct violation of United Nations Office of the High Commission on Human Rights "Convention 169 Concerning Indigenous and Tribal Peoples in Independent Countries." Article 14 1.

2.5 HONDURAS

In 1999, Honduras produced mainly lead and zinc, as well as ancillary copper, gold, and silver, and minor amounts of cadmium associated with the zinc. Industrial minerals include cement, gypsum, limestone, marble, and salt. Honduras exported about 40% of its metals to Europe and much of the remainder to Japan, Mexico, the United States, and Venezuela (Doan, 2000). In 2006, the mineral industry accounted for about 2% of the GDP in Honduras, not including any manufacturing of mineral commodities, such as cement or petroleum refinery products (Anderson, 2008).

Figure B-10: Honduras - 2006 Non-metallic Mineral Production (Anderson, 2008)



A new mining law was passed in 1999 encouraging foreign investment and moderating the tax climate, however, Hurricane Mitch, delayed the implementation of this law until the year 2000. In October of 2006, 13 articles of the General Mining Law of Honduras were found to be unconstitutional by the Supreme Court. Reforms to the law which have been proposed were widely considered to be too weak and the law was widely thought in need of rewriting (Mining Watch, 2007). It is unclear at this time as to the progress of the Honduran Congress in passing a new mining law.

In general, foreign companies investing in mining in Honduras have faced numerous problems including allegations of pollution and squatter invasion. According to the US State Department (2008), industry sources assert that all seven versions of a new Mining Law under consideration by the Honduran Congress would effectively tax mining firms out of existence. It is unknown whether any of these bills will pass, when and with what modifications, and whether the law would address only precious metals or all extractive industries. There is currently a moratorium against new mining concessions in Honduras.

As presented in Table B-10, which presents production summaries for various extracted minerals between 2002 and 2006, the major mineral resources of Honduras consist of aggregate materials, cadmium, clay, copper, gold, gypsum, lead, limestone, and marble (Anderson, 2008). Figure B-11 shows that limestone and aggregate had by far the highest percentage of non-metallic production during 2006.

Table B-10: Honduras - 20002 - 2006 Mineral Production (Anderson, 2008)

Extracted Mineral	Production (metric tons unless noted)				
	2002	2003	2004	2005	2006
Aggregate mineral materials, for construction (thousand metric tons)	29,000	447,000	962,000	1,000,000	1,000,000
Cadmium, Cd content of lead-zinc concentrates	--	--	--	--	--
Clays, unspecified	--	13,983	14,225	14,000	14,000
Copper, run of mine, Cu content	300	300	300	300	300
Gold (kilograms)	4,984	4,494	3,683	4,438	4,100
Gypsum	20,000	19,921	5,725	5,700	5,500
Iron oxide, gross weight, for cement additive	17,000	17,000	17,363	17,000	17,000
Lead, mine output, Pb content of concentrate	8,128	9,014	8,877	10,488	11,775
Limestone (metric tons)	1,358,000	1,326,000	780,000	1,230,000	1,200,000
Marble, for construction (sq. meters)	--	--	--	--	--

In terms of metallic minerals, inadequate transportation in Honduras has hampered the development of mineral resources. In the mid-1990s, the El Mochito Mine, in Santa Bárbara, was the country's only large operating base metal mine. By the end of 2001, the mine's proven and probable reserves stood at 3.4 million tons at an average grade of 6.8% zinc, 1.9% lead, and 78 grams per ton of silver; this was an 18% increase over 2000. Lead and zinc concentrates from the mine in 2000 contributed less than 2% to the GDP, and grew 5% in 2001 after the completion of reconstruction from Hurricane Mitch (Nations Encyclopedia, undated).

Currently, Canadian companies operate most large gold mines in Honduras. Canadian mines include Yamana Gold which operates the open pit, heap leach San Andrés gold mine in the department of Copán; Breakwater Resource which operates a lead/copper/gold mine known as El Mochito in the Northeast of the country; and Goldcorp which acquired the controversial San Martin mine from Glamis Gold in 2006. The San Martin mine is an open pit, heap leach operation which has been in operation since 2001. Goldcorp reports that more than 529,088 ounces of gold have been extracted at the San Martin mine since that time (Mining watch, 2007).

2.5.1.Future Development

At this time, there is considerable uncertainty as to the future of mining in Honduras. There are currently only three major hardrock exploration projects in the country. These projects are being run by First Point Minerals of Canada and Rusoro Mining Limited also of Canada.

The First Point Minerals – Camporo Property was previously known as Cacamuya and is a series of volcanic-hosted, low sulphidation, epithermal, gold-silver veins and disseminated gold mineralization deposit. The Property is 4741 hectares in size and is located in southern Honduras. The Camporo Property has gold values as high as 104.7 grams/tonne (g/t) gold and 743 g/t silver. First Point's Tule Property is an intrusion hosted gold and porphyry copper-gold (Cu-Au). It is located 100 kilometers northeast of Tegucigalpa in Central Honduras. The area of the property is 20,000 hectares(First Point Minerals, undated.)

The Rusoro – Minoro project which was acquired from Mena Resources Inc. has excellent potential for near surface, oxidized, copper/gold deposits. Advanced exploration targets consist of a series of related mineralized bodies ranging in size from five to thirty million tonnes with grades of 0.5 to 1.0% Cu and 0.8 to >2.5 g/t Au (Mena Resources, undated).

As for other commodities, trends indicate a status quo for most minerals with the exception of gypsum and lead. As shown in Table 1, gypsum production has decreased markedly between 2002 and 2006 from 20,000 metric tons to around 5,000. It is uncertain why this trend has occurred. Lead has increased in production over the same period of time from 8,128 metric tons to 11,775 metric tons. It is also uncertain as to why there has been an increase in lead demand.

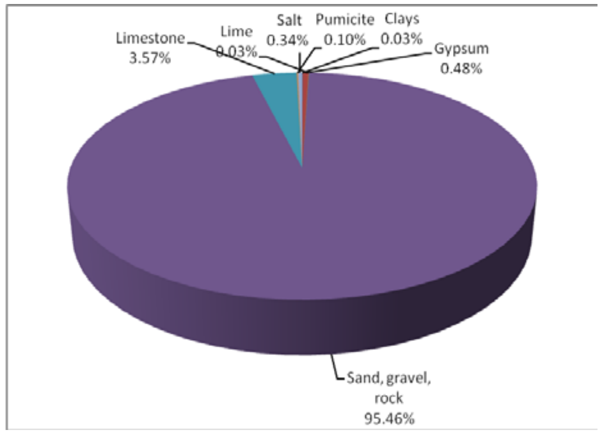
2.5.2.Environmental Concerns

As with other Central American countries, there are numerous concerns about the effects of hardrock mining on the environment and on public health. According to Mining Watch, in July of 2007 major demonstrations took place across Honduras when six major road blockades were erected to protest the possible advancement of a watered down reforms to the General Mining Law. Demonstrators were demanding that the new mining law ban open pit and metallic mining, revoke mining permits from companies who are contaminating the natural environment and cancel concessions in national parks and reserves. Concerns range from potential water shortages to the human health effects from the use of cyanide, deforestation, water pollution and other factors. The Government of Honduras is currently rewriting the mining law the status of which is unknown, as mentioned above. As for other commodities, such as limestone and aggregate mining, concerns with the exception of cyanide are the same. The mining of these minerals will also be affected by the new law once passed.

2.6 NICARAGUA

Not including manufacturing of mineral commodities, such as cement or petroleum refinery products, the mineral industry accounted for about 1% of the GDP in Nicaragua. (Anderson, 2008). As with other countries in Central America, cement and limestone production are the major mineral commodities.

Figure B-11: Nicaragua - 2006 Mineral Production (Anderson, 2008)



Nicaragua has had a long history of gold mining. In the mid-20th century, Nicaragua's world rank in gold production was 15th during the Sandinista era, when the entire mining industry was nationalized. Gold exports reached $39.9 million in 1980, fell to $15 million in 1982, and were then suspended through 1985. The Corporación Nicaragüense de Minas (INMINE), a subsidiary of the government holding company, controlled most of the country's mineral exploration and production. In 2001, the Congress passed a Mining Code despite opposition from small-scale miners and environmentalists, who argued the law would unduly benefit multinational companies and lead to environmental damage. In 1997, a ban on new concessions was lifted (Encyclopedia of Nations, undated).

Table B-11 presents annual production of various extracted mineral commodities for the years 2002 through 2006 based on data from the USGS 2006 Minerals Yearbook (Anderson, 2008). As presented in Figure B-11, crushed stone makes up around 96% of the extracted mineral production in Nicaragua. Limestone production has remained fairly constant over this time frame. Bentonite, lime, pumice, sand and gravel, and crushed stone were also produced, and some gold and silver.

Table B-11: Nicaragua Mineral Production - 2002 – 2006 (Anderson, 2008)

Extracted Mineral	Production (metric tons unless noted)				
	2002	2003	2004	2005	2006
Clays, unspecified	2,771	3,000	3,000	3,000	3,000
Gold, mine output, Au content (kilograms)	3,904	3,439	4,315	3,674	3,395
Gypsum and anhydrite, crude	28,153	30,642	36,466	36,456	42,191
Lime	3,351	2,848	3,482	2,178	2,351
Limestone:					
Calcium carbonate, including for cement	1,316	2,545	2,916	1,412	1,133
Other	290,000	292,000	248,000	292,000	313,000
Pumice, stone (cubic meters)	--	--	120	2,497	510
Pumicite, fine, including pozzolan	14,820	17,129	14,302	9,200	8,370
Salt, marine	29,710	31,320	30,000	30,000	30,000
Sand, unspecified (thousand cubic meters)	273,000	399,000	358,000	374,000	435,000

Extracted Mineral	Production (metric tons unless noted)				
	2002	2003	2004	2005	2006
Silver, mine output, Ag content (kilograms)	2,198	2,040	2,950	2,999	2,929
Stone:					
Crushed	204,000	421,000	722,000	639,000	695,000
Quarried, unspecified	5,859,000	5,443,000	5,250,000	5,707,000	7,272,000
Tuff, volcanic	38	69	124	117	136
Volcanic ash and sand (metric tons)	200	200	200	205	262

After a long period of low production, gold output almost tripled in the late 1990s, from 1,500 kg in 1996 to 4,450 in 1999 (Encyclopedia of Nations, undated). In 2002, output was 3,904 kg. Gold and silver mines were located in the León, Chontales, and Zelaya departments. The principal gold and silver mines in the country are Cerro Moion (La Libertad), which is operated by RNC Gold, and was acquired by Yamana Gold from Canada, and the Limon Mine which is operated by Central Sun Mining Company (Anderson, 2008).

The La Libertad mine is located approximately 110 kilometers due east of Managua, the capital city of Nicaragua The La Libertad mine is an open pit heap leach gold mine. Resources as of December 31, 2004, at La Libertad are estimated to be 37,295,263 tonnes of ore at an average grade of 1.11 g/tonne representing 1,327,391 contained ounces of gold. Operations at La Libertad recently were converted to using a contract miner. Production is increasing with annual projected production at approximately 70,000 ounces of gold per year (RNC, 2005).

The Limon mine has been operating since 1941. Currently the mine is fully mechanized. A 1,000-tonne-per-day mill, built in 1995, consistently recovers 82%-84% of gold in ore. Proven and probable reserves stood at 1.2 million tonnes grading 5.3 g/t (199,300 contained oz) as of December 31, 2006. The Central Sun Mining Company holds a 95% interest in the Limon Mine. The remaining 5% is held by Inversiones Mineras S.A., a holding company representing unionized mine workers in Nicaragua (Central Sun Mining Company, 2009).

2.6.1.Future Development

According to the Northern Miner and Mines and Quarry Database, there are several on-going gold and silver mining exploration projects in Nicaragua. These include 10 gold and silver exploration projects and the reopening of one mine. Companies involved include Central Sun Mining, Inc, Chesapeake Gold Corp, First Point Mineral Corp, Fortress Mineral Corp, and Radius Gold Inc.. As these projects become developed Nicaragua would become once again a major exporter of gold and silver. It is uncertain as to development plans for other extracted commodities.

2.6.2.Environmental Concerns

As with all Central American countries, environmental concerns including the potential for water pollution, deforestation, the hazards of cyanide in the environment, air pollution from dust, increased water use, and other factors are of a concern. To address these concerns, according to the US State Department (2008), the Environment and Natural Resources Law (1996/217) authorizes the Directorate General for Environmental Compliance, Ministry of Natural Resources and the Environment (MARENA), to evaluate investment plans and monitor ongoing operations to verify compliance with environmental standards (as presented in www.marena.gob.ni). The Law on Crimes against the Environment and

Natural Resources (2005/559) includes additional environmental standards. Some investors complain that MARENA takes political considerations into account in determining whether to issue an environmental permit. Budgetary constraints limit MARENA's ability to enforce environmental standards.

In addition to environmental regulation, mining investments are regulated under the Special Law on Mining Prospecting and Exploitation (2001/387), which is now administered by the newly created Ministry of Energy and Mining. The Ministry of Energy and Mining also retains the authority to grant oil and gas exploration concessions. In 2007, the Supreme Court ruled that several oil exploration concessions had been granted without proper consultation with the governments of the autonomous regions on the Atlantic coast, although the concessions were situated outside recognized regional waters. The central government used the ruling as leverage to re-negotiate more favorable terms.

APPENDIX C. REQUIREMENTS AND STANDARDS: CAFTA-DR COUNTRIES, OTHER COUNTRIES AND INTERNATIONAL ORGANIZATIONS

This Appendix summarizes a range of quantitative benchmarks for specific environmental requirements of new mining projects beyond the requirement to develop an EIA and mitigate and avoid adverse environmental impacts. It does not attempt to capture non-quantitative practice standards. The benchmark standards contained within this Appendix include ambient quality and sector-specific performance standards from CAFTA-DR countries, including the United States, and other foreign governments and international organizations. CAFTA-DR country EIA reviewers and preparers might use this information in the absence of such standards or to assess the validity and to evaluate the significance of impacts within EIAs.

The Appendix includes:

- Introduction to environmental laws, standards and requirements
- Ambient Standards for Air and Water Quality
- Mining Sector specific Performance Standards
  - Water Discharge / Effluent Limits
  - Stormwater runoff
  - Air Emission Limits
  - Solid Waste
- International treaties and agreements ratified/signed
- Website References

Section A summarizes ambient freshwater, drinking water and air quality standards, Section B provides an overview of mining-related effluent limits in several countries and the World Bank Group, Section C includes the equivalent information for emissions, and Section D provides links to relevant web sites. To the extent possible, footnotes provide necessary caveats but it is strongly recommended that if this information is used, the reviewer or preparer confirm it is up to date and appropriate for the circumstances.

1 INTRODUCTION TO ENVIRONMENTAL LAWS, STANDARDS AND REQUIREMENTS

There are many approaches to managing environmental problems (see Figure C-1)
Some approaches are purely voluntary – that is, they encourage and assist change but do not require it. Other approaches are regulatory – that is, they require change or specific performance expectations. At the heart of regulatory approaches are environmental requirements-specific practices and procedures required by law to directly or indirectly reduce or prevent pollution. Figure C-2 lists some examples of the types of requirements and standards typically used for environmental management, including:

- Ambient Standards
- Performance Standards (Emissions and Effluents).
- Technology Standards
- Practice Standards
- Information requirements
- Product or Use Bans

While wholly regulatory (command and control) approaches generally have the most extensive requirements of all the management options, most of the other options including market-based economic incentive, labeling and liability based approaches introduce some form of requirements.

Requirements may be general or facility/activity specific. General requirements are most frequently implemented in the form of (1) laws, (2) regulations, or (3) general permits or licenses that apply to a specific class of facilities. General requirements may apply directly to a group of facilities or they may serve as a basis for developing facility-specific requirements. Facility-specific requirements are usually implemented in the form of permits or licenses, or, in the case of environmental impact assessment, may become legally binding commitments if they are a) within the environmental impact assessment itself, b) within a separate environmental management plan or monitoring/mitigation plan, or c) incorporated into a separate contract.

Appendix C benchmarks only quantitative limits and in a highly summarized format as a useful point of reference. For additional background on enforceable requirements see the International Network for Environmental Compliance and Enforcement Website: www.inece.org and specifically the resource library. www.inece.org/library/principles.html. Others references for more details behind the limits summarized in the Appendix are provided in the last section.

FIGURE C-1. APPROACHES TO ENVIRONMENTAL MANAGEMENT

VOLUNTARY APPROACHES

Voluntary approaches encourage or assist, but do not require, change. Voluntary approaches include public education, technical assistance, and the promotion of environmental leadership by industry and nongovernment organizations. Voluntary approaches may also include some management of natural resources (e.g., lakes, natural areas, ground water) to maintain environmental quality.

REGULATORY (COMMAND-AND-CONTROL) APPROACHES

In command-and-control approaches, the government prescribes the desired changes through detailed requirements and then promotes and enforces compliance with these requirements. Table 3-2 describes types of requirements typically used in command-and-control approaches.

MARKET-BASED/ECONOMIC INCENTIVE APPROACHES

Market-based/economic incentive approaches use market forces to achieve desired behavior changes. These approaches can be independent of or build upon and supplement command-and-control approaches. For example, introducing market forces into a command-and-control approach can encourage greater pollution prevention and more economic solutions to problems. Market-based/economic incentive approaches include:

<u>Fee systems</u> which tax emissions, effluents, and other environmental releases.

<u>Tradable</u>permits which allow companies to trade permitted emission rights with other companies.

<u>Offset approaches</u>. These approaches allow a facility to propose various approaches to meeting an environmental goal. For example, a facility may be allowed to emit greater quantities of a substance from one of its operations if the facility offsets this increase by reducing emissions at another of its operations.

<u>Auctions</u>. In this approach, the government auctions limited rights to produce or release certain environmental pollutants.

<u>Environmental labeling/public disclosure</u>. In this approach, manufacturers are required to label products so that consumers can be aware of the environmental impacts of the products. Consumers can then choose which products to purchase based on the products' environmental performance.

RISK-BASED APPROACHES

Risk-based approaches to environmental management are relatively new. These approaches establish priorities for change based on the potential for reducing the risks posed to public health and/or the environment.

POLLUTION PREVENTION

The goal of pollution prevention approaches is to prevent pollution by reducing or eliminating generation of pollution at the source. The changes needed to prevent pollution can be required, e.g., as part of a command-and-control approach, or encouraged as voluntary actions.

LIABILITY

Some environmental management approaches are based on laws that make individuals or businesses liable for the results of certain actions or for damages they cause to another individual or business or to their property. Liability systems do not have explicit requirements. However, implicit requirements often develop as cases are brought to court and patterns are established about what activities justify which consequences. To be effective, liability systems generally need some enforcement by the government, nongovernment organizations, or individuals to gather evidence and develop legal cases. Examples of liability-based environmental management systems include nuisance laws, laws requiring compensation for victims of environmental damage, and laws requiring correction of environmental problems caused by improper disposal of hazardous waste. Liability systems reduce or prevent pollution only to the extent that individuals or facilities fear the consequences of potential legal action against them.

FIGURE C-2. EXAMPLES OF ENVIRONMENTAL REQUIREMENTS

Ambient Standards

Ambient standards (also called media quality standards) are goals for the quality of the ambient environment (e.g., air, water). Ambient standards are usually written in units of concentration (e.g., the level of nitrogen dioxide in the air cannot exceed 0.053 parts per million). In the U.S., ambient standards are used as environmental quality goals and to plan the level of emissions from individual sources that can be accommodated while still meeting the area wide goal. Ambient standards may also be as triggers, e.g., when the standard is exceeded, monitoring or enforcement efforts are increased. Enforcement of ambient standards usually requires relating an ambient measurement to emissions or activities at a specific facility. This can be difficult.

Performance Standards (Emissions and Effluents)

These standards are widely used for regulations, permits, and monitoring requirements. Performance standards limit the amount or rate of particular chemicals or discharges that a facility can release into the environment in a given period of time. Performance standards provide flexibility because they allow sources to choose which technologies they will use to meet the standards. Often such standards are based on the output that can be achieved using the best available control technology. Some requirements introduce additional flexibility by allowing a source with multiple emissions to vary its emissions from each stack as long as the total sum of the emissions does not exceed the permitted total. Compliance with emission standards is measured by sampling and monitoring. Depending on the kind of instruments required, compliance can be difficult and/or expensive to monitor.

Technology Standards

These standards require the regulated community to use a particular type of technology (e.g., the "best available technology") to control and/or monitor emissions. Technology standards are particularly appropriate when the equipment is known to perform well under the range of conditions generally experienced by sources in the community. It is relatively easy for inspectors to determine whether sources are in compliance with technology standards: the approved equipment must be in place and operating properly. It may be difficult, however, to ensure that the equipment is operating properly over a long period of time. Technology standards can inhibit technological innovation and pollution prevention.

Practice Standards

These standards require or prohibit certain work activities that have significant environmental impacts. For example, a standard might prohibit carrying hazardous liquids in uncovered buckets. Like technology standards, it is easy for program officials to inspect for compliance and take action against noncomplying sources, but difficult to ensure ongoing compliance.

Information Requirements

These requirements are different from the standards described above in that they require a source of potential pollution (e.g., a pesticide manufacturer or facilities involved in generating, transporting, storing, treating, and disposing of hazardous waste) to develop and submit information to the government. Sources generating pollution may be required to monitor, report on, and maintain records of the level of pollution generated and whether or not it exceeds performance standards. Information requirements are often used when the potential pollution source is a product such as a new chemical or pesticide, rather than a waste. For example, a manufacturer may be required to test and report on a product's potential to cause harm if released into the environment.

Product or Use Bans

A ban may prohibit a product outright (e.g., ban the manufacture, sale, and/or use of a product) or may prohibit particular uses of a product.

2 AMBIENT STANDARDS FOR AIR AND WATER QUALITY

The following Tables summarize and compare across countries and institutions standards for:

- Freshwater Quality Guidelines and Standards
- Drinking Water Standards
- Air Quality Standards

Table C-1 Freshwater Quality Guidelines and Standards

Pollutant	United States		European Union	
	National Recommended Water Quality Criteria[1]		Environmental Quality Standards (EQS)	
	Criteria Maximum Concentration (CMC) (µg/l)	Criteria Continuous Concentration (CCC) (µg/l)	Annual Average Value (Inland surface Waters) (µg/l)	Maximum Allowable Concentration (Inland surface Waters) (µg/l
Alachlor			0.3	0.7
Anthracene			0.1	0.4
Arsenic	340	150		
Atrazine			0.6	2.0
Benzene			10	50
Benzo(a)pyrene			0.05	0.1
Brominated diphenylether			0.0005	N/A
Cadmium	2	0.25	≤ 0.08 (Class 1)[2] 0.08 (Class 2) 0.09 (Class 3) 0.15 (Class 4) 0.25 (Class 5)	≤ 0.45 (Class 1) 0.45 (Class 2) 0.09 (Class 3) 0.15 (Class 4) 0.25 (Class 5)
C 10-13 Chloralkanes			0.4	1.4
Chlordane	2.4	0.0043		
Chlorfenvinphos			0.1	0.3
Chloride	860,000	230,000		
Chromium (III)	570	74		
Chromium (VI)	16	11		
Chlorpyrifos (Chlorpyrifos-ethyl)			0.03	0.1
Cyanide	22	5.2		
DDT total			0.025	N/A
Para-para-DDT			0.01	N/A
1,2-Dichloroethane			10	N/A
Dichloromethane			20	N/A
Dieldrin	0.24	0.056	∑=0.01 [3]	N/A
Di(2-ethylexyl)-phthalate (DEPH)			1.3	N/A
Diuron			0.2	1.8
alpha-Endosulfan	0.22	0.056	0.005	0.01

1 In the United States, the federal government issues recommended water quality criteria to provide for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water but it is up to the states in the first instance, to adopt binding water quality criteria based on designated use categories. .

2 For cadmium and its compounds the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO3/l,Class 2: 40 to < 50 mg CaCO3/l, Class 3: 50 to < 100 mg CaCO3/l, Class 4: 100 to < 200 mg CaCO3/l and Class 5: ≥ 200 mg CaCO3/l).

3 Suma for cyclodiene pesticides which include: Aldrin, Dieldrin, Endrin, Isodrin

Pollutant	United States		European Union	
Fluoranthene			20	N/A
Heptachlor	0.52	0.0038		
Heptachlor Epoxide	0.52	0.0038		
Hexachloro-benzene			0.01	0.05
Hexachloro-butadiene			0.1	0.6
Hexachloro-cyclohexane			0.02	0.04
Isoproturon			0.3	1.0
Lead	65	2.5	7.2	N/A
Mercury	1.4	0.77	0.05	0.07
Naphthalene			2.4	N/A
Nickel	470	52	20	N/A
Nonylphenol (4-Nonylphenol)			0.3	2.0
Octylphenol			0.1	N/A
Pentachloro-benzene			0.007	N/A
Pentachlorophenol	19	15	0.4	1.0
Polychlorinated Biphenyls (PCBs)		0.014		
Selenium		5		
Simazine			1.0	4.0
Silver	3.2			
Sulphate			129.75 mg/l	4,200 mg/l
Tetrachloroethylene			10.0	N/A
Trichloroethylene			10	N/A
Toxaphene	0.73	0.0002		
Tributyltin compounds			0.0002	0.0015
Trichloro-benzenes			0.4	N/A
Trichloro-methane			2.5	N/A
Trifluralin			0.03	N/A
Zinc	120	120		

Sources: US: http://www.epa.gov/waterscience/criteria/wqctable/index.html#cmc
EU: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0084:0097:EN:PDF

Table C-2 Drinking Water Quality Guidelines and Standards

	United States		Canada	European Union	World Health Organization
Pollutant	Maximum Contaminant Level Goal	Maximum Contaminant Level	Maximum Acceptable Concentration	Parametric Value	Guideline Value
Acrylamide				0.1 µg/l	
Ammonium				0.50 mg/l	
Aluminum			0.1/0.2 mg/l (100 - 200 µg/l)	200 µg/l	
Antimony	0.006 mg/l (6 µg/l)	0.006 mg/l	0.006 (6 µg/l)	5.0 µg/l	
Arsenic	0	0.01 mg/l	0.1 mg/l (10 µg/l)	10 µg/l	10 µg/l
Asbestos	7 million fibers per liter	7 million fibers per liter			
Barium	2 mg/l (2000 µg/l)	2 mg/l (2000 µg/l)	1 mg/l (1000 µg/l)		
Benzene			0.005 mg/l (5 µg/l)	1.0 µg/l	
Benzo(a)pyrene			0.00001 mg/l (0.01 µg/l)	0.010 µg/l	
Beryllium	0.004 mg/l (4 µg/l)	0.004 mg/l (4 µg/l)			
Boron			5 mg/l (5000 µg/l)	1.0 mg/l	
Bromate	0	0.010 mg/l (10 µg/l)	0.01 mg/l (10 µg/l)	10 µg/l	
Bromodichloro-methane (BDCM)			0.016 mg/l (16 µg/l)	100 µg/l	0.06 mg/l (60 µg/l)
Cadmium	0.005 mg/l (5 µg/l)	0.005 mg/l (5 µg/l)	0.005 mg/l (5 µg/l)	5.0 µg/l	
Chlorate			1 mg/l (1000 µg/l)		
Chloride				250 mg/l	
Clostridium perfringens				0 number/100 ml	
Conductivity				2 500 µS cm^{-1} at 20 °C	
Chlorite	0.8 mg/l (800 µg/l)	1.0 mg/l (1000 µg/l)	1 mg/l (1000 µg/l)		
Chromium (total)	0.1 mg/l (100 µg/l)	0.1 mg/l (100 µg/l)	0.05 mg/l (50 µg/l)	50 µg/l	0.05 mg/l (50 µg/l)
Copper	1.3 mg/l	1.3 mg/l		2.0 mg/l	2.0 mg/l

	United States		Canada	European Union	World Health Organization
Pollutant	Maximum Contaminant Level Goal	Maximum Contaminant Level	Maximum Acceptable Concentration	Parametric Value	Guideline Value
Cyanide (as free cyanide)	0.2 mg/l (200 µg/l)	0.2 mg/l (200 µg/l)	0.2 mg/l (200 µg/l)	50 µg/l	
Cyanobacterial toxins -- microcystin-LR			0.0015 mg/l (1.5 µg/l)		
1,2-dichloroethane				3.0 µg/l	
Epichlorohydrin				0.10 µg/l	
Fluoride	4 mg/l	4 mg/l	1.5 mg/l	1.5 mg/l	1.5 mg/l
Iron				200 µg/l	
Lead	0	0.015 mg/l (15 µg/l)	0.01 mg/l (10 µg/l)	10 µg/l	
Manganese				50 µg/l	
Mercury (inorganic)	0.002 mg/l (2 µg/l)	0.002 mg/l (2 µg/l)	0.001 mg/l (1 µg/l)	1.0 µg/l	
Nickel				20 µg/l	0.07 mg/l (70 µg/l)
Nitrate (measured as Nitrogen)	10 mg/l	10 mg/l	45 mg/l	50 mg/l	50 mg/l
Nitrite (measured as Nitrogen)	1 mg/l	1 mg/l	3.2 mg/l	0.50 mg/l	0.2 mg/l
Nickel				20 µg/l	0.07 mg/l (70 µg/l)
Nitrate				50 mg/l	
Nitrite				0.50 mg/l	
Pesticides				0.10 µg/l	
Pesticides - Total				0.50 µg/l	
Polycyclic aromatic hydrocarbons				0.10 µg/l	
Selenium	0.05 mg/l (50 µg/l)	0.05 mg/l (50 µg/l)	0.01 mg/l (10 µg/l)	10 µg/l	0.01 mg/l (10 µg/l)
Sulfate				250 mg/l	
Sodium				200 mg/l	
Tetrachloroethene and Trichloroethene				10 µg/l	0.07 mg/l (70 µg/l)
Thallium	0.0005 mg/l	0.002 mg/l			

	United States		Canada	European Union	World Health Organization
Pollutant	Maximum Contaminant Level Goal	Maximum Contaminant Level	Maximum Acceptable Concentration	Parametric Value	Guideline Value
	(0.5 µg/l)	(2 µg/l)			
Trihalomethanes (total)	N/A	0.080 mg/l (80 µg/l)		100 µg/l	
Vinyl Chloride				0.50 µg/l	
pH			6.5-8.5	6.5-9.5	

Sources: US Drinking Water Standards: http://www.epa.gov/ogwdw000/contaminants/index.html
WHO Guidelines for Drinking-Water Quality p.186, http://www.who.int/water_sanitation_health/dwq/fulltext.pdf

EU Quality Standards of Water Intended for Human Consumption:
http://eur-lex.europa.eu/LexUriServ/LexUriserv.do?uri=CONSLEG:1998L0083:20030807:EN:PDF

Table C-3 Ambient Air Quality Guidelines and Standards

Pollutant	World Health Organization (WHO) Ambient Air Quality Guidelines		United States National Ambient Air Quality Standards				European Commission Air Quality Standards			Canada National Ambient Air Quality Objectives & Guidelines			
			Primary Standards		Secondary Standards								
	Averaging Period	Guideline Value ($\mu g/m^3$)	Averaging Period	Level	Averaging Period	Level	Averaging Period	Concentration	Permitted Exceedences Per Year	Averaging Time	Maximum Desirable Level	Maximum Acceptable Level	Maximum Tolerable Level
Sulfur Dioxide (SO_2)	24 hour	125 (interim target 1) 50 (interim target 2) 20 (guideline)	24 hour	0.14 ppm	3 hour	0.5 ppm	1 hour	350 $\mu g/m^3$	24	1 hour	172 ppb	334 ppb	N/A
	10 minute	500 (guideline)	1 year	0.030 ppm			24 hour	125 $\mu g/m^3$	3	24 hour	57 ppb	115 ppb	306 ppb
										1 year	11 ppb	23 ppb	N/A
Nitrogen Dioxide (NO2)	1 year	40 (guideline)	1 year	53 ppb (100 µg/m3)	1 year	0.053 ppm (100 $\mu g/m^3$)	1 year	200 $\mu g/m^3$	N/A	1 year	32 ppb	53 ppb	N/A
	1 hour	200 (guideline)	1 hour	100 ppb	N/A	N/A	1 hour	40 $\mu g/m^3$	18	24?hour	N/A	106 ppb	160 ppb
										1?hour	N/A	213 ppb	532 ppb
Total Suspended Particulate (TSP)							1 year	N/A	120 $\mu g/m^3$	400 $\mu g/m^3$			
							24 hour	60 $\mu g/m^3$	70 $\mu g/m^3$	N/A			
Particulate Matter (PM10)	1 year	70 (interim target 1) 50 (interim target 2) 30 (interim target 3) 20 (guideline)	24 hour	150 $\mu g/m^3$	24 hour	150 $\mu g/m^3$	24 hour	50 $\mu g/m^3$	35				
	24 hour	150 (interim target 1) 100 (interim target 2) 75 (interim target 3) 50 (guideline)					1 year	40 $\mu g/m^3$	N/A				
Particulate Matter (PM2.5)	1?year	35 (interime target 1) 25 (interim target 2) 15 (interim target 3) 10 (guideline)	1?year	15.0 $\mu g/m^3$	1?year	15.0 $\mu g/m^3$	1?year	25 $\mu g/m^3$	N/A				
	24?hour	75 (interim target 1) 50 (interim target 2) 37.5 (interim target 3) 25 (guideline)	24?hour	35 $\mu g/m^3$	24?hour	35 $\mu g/m^3$							
Ozone	8 hour	160 (interim target 1) 100 (guideline)	1 hour**	0.12 ppm (235 $\mu g/m^3$)	1 hour**	0.12 ppm (235 $\mu g/m^3$)	8 hour	120 $\mu g/m^3$	25 days averaged over 3 years	1 year	N/A	15 ppb	N/A
			8 hour	0.075 ppm	8 hour	0.075 ppm				24 hour	15 ppb	25 ppb	N/A
										1 hour	51 ppb	82 ppb	153 ppb
Lead (Pb)	N/A	N/A	3 month	0.15 $\mu g/m^3$	3 month	0.15 $\mu g/m^3$	1 year	0.5 $\mu g/m^3$	N/A				
Carbon Monoxide (CO)	N/A	N/A	1 hour	35 ppm (40 mg/m^3)			8 hour	10 mg/m^3	N/A	1 hour	13 ppm	31 ppm	N/A
			8 hour	9 ppm (10 mg/m^3)						8 hour	5 ppm	13 ppm	17 ppm
Benzene							1 year	5 $\mu g/m^3$	N/A				
Arsenic (As)							1 year	6 ng/m^3	N/A				
Cadmium (Cd)							1 year	5 ng/m^3	N/A				
Nickel (Ni)							1 year	20 ng/m^3	N/A				
Polycyclic Aromatic Hydrocarbons							1?year	1 ng/m^3 (expressed as a concentration of Benzo(a)pyrene)	N/A				

* Target value enters into force 1.1.2012
** The 1 hour U.S. Oxone standard was revoked beginning on June 15, 2005, and is being replaced by the 8 hour standard.

Sources for "Ambient Air Quality Standards and Guidelines":
European Commission Air Quality Standards: http://ec.europa.eu/environment/air/quality/standards.htm
Canadian National Ambient Air Quality Objectives: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/reg-eng.php
WHO (quoted in International Finance Corporation Environmental, Health, and Safety General Guidelines): http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeneralEHS/$FILE/Final+-+General+EHS+Guidelines.pdf
US National Ambient Air Quality Standards: http://epa.gov/air/criteria.htm

3 MINING SECTOR SPECIFIC PERFORMANCE STANDARDS

3.1 Mining Sector Water Discharge/ Effluent Limits

Table C-4 Mining Sector Water Discharge / Effluent Limits in CAFTA-DR Countries, Canada, and the IFC / World Bank

Pollutant	Costa Rica	Dominican Republic	Nicaragua	United States	World Bank/IFC	Canada
	Effluent Limits for Mining Activities	Effluent Limits for Metal Mining	Proposed Effluent Limits for Mining and Metal Finishing	Effluent Limitations	Maximum Effluent Values	Metal Mining Effluent Regulations
Aluminum	5 mg/l		2 mg/l	See Supplemental Section 3.2 with U.S. effluent limitations for specific categories of ores and processes related to mining.		
Arsenic	0.1 mg/l	0.1 mg/l			0.1 mg/l	0.5 - 1 mg/l
Barium	5 mg/l					
Boron	3 mg/l					
Cadmium	0.1 mg/l	0.1 mg/l	0.1 mg/l		0.1 mg/l	
Carbamates (total)	0.1 mg/l					
Chemical Oxygen Demand (COD)		150 mg/l			150 mg/l	
Chlorine (residual)	1 mg/l					
Chromium	1.5 mg/l	0.1 mg/l (hexavalent)	1 mg/l (total), 0.5 mg/l (hexavalent)		0.1 mg/l (hexavalent)	
Color (purity)	15%					
Copper	0.5 mg/l	0.5 mg/l	0.5 mg/l		0.5 mg/l	0.3 - 0.6 mg/l
Cyanide (total)	1 mg/l	1.0 mg/l	1 mg/l		1 mg/l	1 - 2 mg/l
Cyanide (free)	0.1 mg/l	0.1 mg/l			0.1 mg/l	
Cyanide (free in recipient body, outside mixing area)	0.005 mg/l					
Cyanide (weak acid dissociable)	0.5 mg/l	0.5 mg/l			0.5 mg/l	
Fluoride	10 mg/l					
Hydrocarbons	10 mg/l					
Iron		3.5 mg/l			3.5 mg/l	

Table C-4 Mining Sector Water Discharge/ Effluent Limits in CAFTA-DR Countries, Canada, and the IFC / World Bank (continued)

Pollutant	Costa Rica	Dominican Republic	Nicaragua	United States		World Bank/IFC	Canada
	Effluent Limits for Mining Activities	Effluent Limits for Metal Mining	Proposed Effluent Limits for Mining and Metal Finishing	Effluent Limitations		Maximum Effluent Values	Metal Mining Effluent Regulations
Lead	0.5 mg/l	0.2 mg/l	0.5 mg/l	See Supplemental Section 3.2 with U.S. effluent limitations for specific categories of ores and processes related to mining.		0.2 mg/l	0.2 - 0.4 mg/l
Mercury	0.01 mg/l	0.01 mg/l				0.01 mg/l	
Nickel	1 mg/l	0.5 mg/l	1 mg/l			0.5 mg/l	0.5 - 1.0 mg/l
Nitrogen (total)	50 mg/l						
Oil and Grease		10 mg/l				10 mg/l	
Organophosphorus Compounds (total)	0.1 mg/l						
Organochlorine Compounds (total)	0.05 mg/l						
Radium 226							0.37 - 1.11 Bq/l
Selenium	0.05 mg/l						
Settleable Solids			1 ml/l				
Silver	1 mg/l						
Sulfites	1 mg/l						
Sulphides	25 mg/l						
Tin	2 mg/l						
Total Metals		10.0 mg/l				10 mg/l	
Total Suspended Solids (TSS)		50 mg/l	50 mg/l			50 mg/l	15 - 30 mg/l
Zinc	5 mg/l	2.0 mg/l	1 mg/l			2 mg/l	0.5 - 1 mg/l
Temperature			40 °C				
pH		6.0-9.0	6.0-9.0			6.0-9.0	

Sources: World Bank Group / IFC – World Bank Group Project Guidelines: Base Metal and Iron Ore Mining, p. 270 (effective July 1998); Canada – Fisheries Act Subsections 34(2), 36(5), and 38(9) (registered June 6, 2002); Costa Rica – Reglamento de Vertido y Reuso de Aguas Residuales Decreto N°33601 Artículo 21 (Tabla 5); Dominican Republic – Norma Ambiental sobre Calidad del Agua y Control de Descarga (6/2003); Nicaragua – Reglamento de Verido y Aguas Resduales (Proposed Regulation); United States – See supplemental section 3.2 with excerpted performance standards from US Code of Federal Regulations Title 40 Part 440 (last amended May 24, 1988) (Ore Mining and Dressing); See also 40 CFR part 434 (Coal Mining) and part 436 (Mineral Mining and Processing).

3.2. Supplemental U.S. Water Discharge / Effluent Limits for the Mining Sector

Discharges of pollutants from any point source into the waters of the U.S. are prohibited except as in compliance with the Clean Water Act. 33 U.S.C. § 1311. Usually this means that for discharges to be lawful they must be authorized by permit (The Clean Water Act section 301). Discharge permits are issued either by EPA or States with programs approved by EPA administering what is called the National Pollutant Discharge Elimination System (NPDES), or in the case of dredged or fill material the U.S. Army Corps of Engineers or a state authorized to administer a permit program for such discharges with EPA objection rights. 33 U.S.C. §§ 1342, 1344. NPDES permits must contain conditions that, at a minimum, meet water quality standards and technology-based effluent performance limits, which for many ore mining categories, are found at 40 CFR part 440. EPA takes into account both technology and economics into account when it promulgates nationwide effluent limitation guidelines, and the basis for the standards is accessible via the EPA website (http://water.epa.gov/scitech/wastetech/guide/). The limits listed for reference here are current as of 2009. Users should cross check the EPA website for any updates.

Table C-5 Overview of US Water Regulations Impacting the Mining Industry

Facility or Resource Type	Environmental Concern	Relevant Statute	Relevant Rule or Regulation	Relevant Table	Website Reference
Metal Mines and Mills	Effluent levels of mine water discharge	Clean Water Act (CWA)	40 CFR 440 -- Ore Mining and Dressing Point Source Category (Subparts A-M)	"US Effluent Limitations for Metal Mines and Mills"	http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=29906bec440a53789ceba96d841cc756;rgn=div5;view=text;node=40%3A29.0.1.1.16;idno=40;cc=ecfr
Mineral Mines	Effluent levels of mine water discharge	Clean Water Act (CWA)	40 CFR 436 -- Mineral Mining and Processing Point Source Category	"US Effluent Limitations for Sand & Gravel Mining"	http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=29906bec440a53789ceba96d841cc756;rgn=div5;view=text;node=40%3A29.0.1.1.12;idno=40;cc=ecfr#40:29.0.1.1.12.6.4.3
Freshwater Systems	Contamination of US freshwater systems	Clean Water Act (CWA)	National Recommended Water Quality Criteria (EPA website)	"US National Recommended Freshwater Quality Standards"	http://www.epa.gov/waterscience/criteria/wqctable/index.html#cmc
Drinking Water Systems	Health impacts of contamination of US drinking water	Safe Drinking Water Act (SDWA)	Drinking Water Contaminants (EPA website)	"US Drinking Water Contaminants MCLGs and MCLs (Inorganic Chemicals)"	http://www.epa.gov/safewater/contaminants/index.html#8
Drinking Water Systems	Aesthetic characteristics or cosmetic effects of US drinking water	Safe Drinking Water Act (SDWA)	National Secondary Drinking Water Regulations (NSDWRs) (EPA website)	"US Federal Secondary Drinking Water Standards"	http://www.epa.gov/safewater/contaminants/index.html#8

Table C-6 Mine Discharges Subject to Permitting in the US

Runoff/drainage discharges subject to 40 CFR Part 440 effluent limitation guidelines	Subject to storm water permitting (not subject to 40 CFR Part 440)
Land application area	Topsoil piles
Crusher area	Haul roads not on active mining area
Spent ore piles, surge piles, ore stockpiles, waste rock/overburden piles	On-site haul roads not constructed of waste rock or spent ore (unless wastewater subject to mine drainage limits is used for dust control)
Pumped and unpumped drainage and mine water from pits/underground mines	Tailings dams, dikes when not constructed of waste rock/tailings
Seeps/French drains	Concentration/mill building/site (if discharge is storm water only, with no contact with piles)
On-site haul roads, if constructed of waste rock or spent ore or if wastewater subject to mine drainage limits is used for dust control	Reclaimed areas released from reclamation bonds prior to December 17, 1990
Tailings dams/dikes when constructed of waste rock/tailings	Partially, inadequately reclaimed areas or areas not released from reclamation bond
Unreclaimed disturbed areas	Most ancillary areas (e.g. chemical and explosive storage, power plant, equipment/truck maintenance and wash areas, etc.)

Source: Profile of the Metal Mining Industry: EPA Office of Compliance Sector Notebook, p. 87
http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/metminsn.pdf

Table C-7
US Effluent Limitations for Mining and Processing of Sand and Gravel
(Process Generated Waste Water and Mine Dewatering Discharges)

	Construction Use (14)			
	Process Generated Waste Water		Mine Dewatering Discharges	
	1 Day	30 Day Avg.	1 Day	30 Day Avg.
pH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0

		Industrial Use (15)					
		Process Generated Waste Water (HF Flotation)		Process Generated Waste Water (No HF Flotation)		Mine Dewatering Discharges	
		1 Day	30 Day Avg.	1 Day	30 Day Avg.	1 Day	30 Day Avg.
Effluent Characteristic	pH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0
	Total Suspended Solids (TSS)	0.046 kg/kkg	0.023 kg/kkg	45 mg/l	25 mg/l	45 mg/l	25 mg/l
	Total Flouride	0.006 kg/kkg	0.003 kg/kkg				

Source: US Code of Federal Regulations Title 40 Part 436 Subparts C-D (last amended July 12, 1995).
Subpart C – Construction Sand and Gravel:
http://frwebgate3.access.gpo.gov/cgi-bin/TEXTgate.cgi?WAISdocID=94272926199+37+1+0&WAISaction=retrieve
Subpart D – Industrial Sand:
http://frwebgate3.access.gpo.gov/cgi-bin/TEXTgate.cgi?WAISdocID=94272926199+36+1+0&WAISaction=retrieve

Table C-8 US Effluent Limitations for Metal Mines and Mills (40 CFR Part 440)

		Metal Being Mined or Processed									
		Iron (1)		Copper, Lead, Zinc, Silver, Gold (non-placer mines) (2)		Molybdenum (3)		Gold (placer mines)		Nickel	
		1 Day	Avg. (30 days)	1 Day	Avg. (30 days)	1 Day	Avg. (30 days)	1 Day	Avg. (30 days)	1 Day	Avg. (30 days)
Pollutants	Total Suspended Solids (TSS)	30 mg/l	20 mg/l	30 mg/l	20 mg/l	30 mg/l 50 mg/l (4)	20 mg/l 30 mg/l (4)	n/a	n/a	30mg/l 50 mg/l (5)	20 mg/l 30 mg/l (5)
	Iron (Fe) (Dissolved)	2.0 mg/l	1.0 mg/l	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Copper (Cu)	n/a	n/a	.30 mg/l	.15 mg/l	.3 mg/l	.15 mg/l	n/a	n/a	.30 mg/l	.15 mg/l
	Zinc (Zn)	n/a	n/a	1.0 mg/l (6) 1.5 mg/l (7)	.5 mg/l (6) .75 mg/l (7)	1.0 mg/l	.5 mg/l	n/a	n/a	1.0 mg/l	.5 mg/l
	Lead (Pb)	n/a	n/a	.6 mg/l	.3 mg/l	.6 mg/l (8)	.3 mg/l (8)	n/a	n/a	.6 mg/l (9)	.3 mg/l (9)
	Mercury (Hg)	n/a	n/a	.002 mg/l	.001 mg/l	n/a	n/a	n/a	n/a	n/a	n/a
	Cadmium (Cd)	n/a	n/a	.10 mg/l	.05 mg/l	.10 mg/l (10)	.05 mg/l (10)	n/a	n/a	.10 mg/l	.05 mg/l
	Arsenic (As)	n/a	n/a	n/a	n/a	1.0 mg/l (11)	.5 mg/l (11)	n/a	n/a	1.0 mg/l (12)	.5 mg/l (12)
	Settleable Solids	n/a	n/a	n/a	n/a	n/a	n/a	0.2 ml/l (13)	0.2 ml/l (13)	n/a	n/a
	pH Range	6.0-9.0		6.0-9.0		6.0-9.0		6.0-9.0		6.0-9.0	

Source: US Code of Federal Regulations Title 40 Part 440 (last amended May 24, 1988).http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=ce9b752a1e80c7deda2119a173134896&rgn=div6&view=text&node=40:29.0.1.1.16.10&idno=40

NOTES to "US Effluent Limitations for Metal Mines and Mills (40 CFR Part 440)":

1. Applies to discharges from (a) mines operated to obtain iron ore, regardless of the type of ore or its mode of occurrence; (b) mills beneficiating iron ores by physical (magnetic and nonmagnetic) and/or chemical separation; and (c) mills beneficiating iron ores by magnetic and physical separation in the Mesabi Range. §440.10.
2. Applies to (a) mines that produce copper, lead, zinc, gold, or silver bearing ores, or any combination of these ores from open-pit or underground operations other than placer deposits; (b) mills that use the froth-flotation process alone or in conjunction with other processes, for the beneficiation of copper, lead, zinc, gold, or silver ores, or any combination of these ores; (c) mines and mills that use dump, heap, in-situ leach, or vat-leach processes to extract copper from ores or ore waste materials; and (d) mills that use the cyanidation process to extract gold or silver. §440.100.
3. Applies to mines that produce molybdenum bearing ores from open-pit or underground operations other than placer deposits and mills that use the froth-flotation process alone or in conjunction with other processes, for the beneficiation of molybdenum ores. §440.100.

4 Applies to discharges from mines producing less than 5,000 metric tons or mills processing less than 5,000 metric tons of molybdenum per year by processes other than ore leaching. §440.102(f).
5 Applies to pollutants discharged in mine drainage from mines producing less than 5,000 metric tons or discharged from mills processing less than 5,000 metric tons of nickel ores per year by methods other than ore leaching. § 440.72(b).
6 Applies to pollutants discharged from mills which employ the froth flotation process alone or in conjunction with other processes, for the beneficiation of copper ores, lead ores, zinc ores, gold ores, or silver ores, or any combination of these ores. Includes both new and existing sources. §440.102(b); §440.103(b).
7 Applies to pollutants discharged in mine drainage from mines operated to obtain copper bearing ores, lead bearing ores, zinc bearing ores, gold bearing ores, or silver bearing ores, or any combination of these ores through open-pit or underground operations other than placer deposits. §440.102(a); §440.103(a).
8 Applies only to pollutants discharged in main drainage from mines (not mills) producing 5,000 metric tons or more of molybdenum bearing ores per year. §440.102(e).
9 Applies only to drainage from mines (not mills) producing 5,000 metric tons or more of nickel ores every year. §440.72(a).
10 Does <u>not</u> apply to mines producing fewer than 5,000 metric tons of molybdenum bearing ore per year. §440.102(f).
11 Applies to pollutants discharged in mine drainage from mines producing 5,000 metric tons or more of molybdenum bearing ores per year, pollutants discharged from mills processing 5,000 metric tons or more of molybdenum per year by purely physical methods such as crushing, washing, jigging, or heavy media separation, or by froth flotation methods. §440.102(e), (g)-(h).
12 Does <u>not</u> apply to mines producing fewer than 5,000 metric tons of nickel bearing ore per year. §440.72(b).
13 Applies to pollutants in process wastewater discharges from open-cut mine plants and dredge plant sites. §440.142-144.

<u>NOTES to “US Effluent Limitations for Sand & Gravel Mining (Process Generated Waste Water and Mine Dewatering Discharges)”:</u>

14 Applies to the mining and the processing of sand and gravel for construction or fill uses, except that on-board processing of dredged sand and gravel which is subject to the provisions of 33 CFR Part 230. § 436.30
15 Applies to the mining and the processing of sand and gravel for uses other than construction and fill. These uses include, but are not limited to glassmaking, molding, abrasives, filtration, refractories, and refractory bonding. § 436.40

3.3. Storm water Runoff Performance Requirements for the Mining Sector

In the United States, the Environmental Protection Agency (USEPA) issued in 2008 an updated Multi-Sector General Permit (MSGP) for storm water runoff associated with industrial sources. The MSGP identifies specific actions facility operators must take to qualify for a permit, including the submission of a Notice of Intent (NOI), the installation of storm water control measures aimed at minimizing pollutants in storm water runoff, and the formulation of a storm water pollution prevention plan (SWPPP). Although the MSGP only applies in states to which EPA has not delegated permitting authority (5 states at the time of this writing), it provides a useful standard for determining allowable pollutant levels in storm water runoff. For more information on where MSGP requirements apply, see Appendix C of the 2008 MSGP (available at http://www.epa.gov/npdes/pubs/msgp2008_appendixc.pdf).

The US MSGP includes several types of required analytical monitoring, one or more of which may apply to a given facility. These monitoring types include: quarterly benchmark monitoring, annual effluent limitations guidelines monitoring, State- or Tribal-specific monitoring, impaired waters monitoring, and other monitoring as required by EPA. EPA has issued several documents to assists industry in complying with the MSGP monitoring requirements, including the *Industrial Storm water Monitoring and Sampling Guide* (available at http://www.epa.gov/npdes/pubs/msgp_monitoring_guide.pdf).

Under US requirements, benchmark monitoring must be conducted once every three months for the first year of operation under a new permit. Benchmark concentrations are not strict effluent limitations, and they are intended primarily to assist permittees in evaluating the effectiveness of their pollution prevention measures. Consequently, failure to meet a benchmark standard does not result in a permit violation. However, where the average monitoring value for four consecutive quarters exceeds the benchmark, a permittee must undertake a review of the facility's control measures to determine if they are adequate to meet the permit's effluent limits.

Within the mining sector, benchmark concentrations are organized by subsector, such as Subsector G1, which applies to active copper ore mining and dressing facilities, and Subsector G2, covering iron ores, copper ores, lead and zinc ores, gold and silver ores, ferroalloy ores (except vanadium), and miscellaneous metal ores (see tables below). Permittees should be aware that a single facility may be subject to monitoring requirements under multiple subsectors.

Table C-9 US Benchmark Monitoring Concentrations for Subsector G1: Active Copper Ore Mining and Dressing Facilities

		Benchmark Monitoring Concentration
Parameters	Total Suspended Solids (TSS)	100 mg/l
	Nitrate plus Nitrite Nitrogen	0.68 mg/l
	Chemical Oxygen Demand (COD)	120 mg/l

Source: Multi-Sector General Permit for Storm water Discharges Associated with Industrial Activity (MSGP): Authorization to Discharge Under the national Pollutant Discharge Elimination System, p. 66 (Effective May 27, 2009). http://www.epa.gov/npdes/pubs/msgp2008_finalpermit.pdf

Table C-10 US Benchmark Monitoring Concentrations for Subsector G2 (Discharge from Waste Rock and Overburden Piles)

Subsector	Parameter	Benchmark Monitoring Cutoff Concentration
Subsector G2: Iron Ores; Copper Ores; Lead and Zinc Ores; Gold and Silver Ores; Ferroalloy Ores, Except Vanadium; and Miscellaneous Metal Ores	Total Suspended Solids (TSS)	100 mg/l
	Turbidity	50 NTU
	pH	6.0-9.0 s.u.
	Hardness	No Benchmark Value
	Total Antimony	0.64 mg/l
	Total Arsenic	0.15 mg/l
	Total Beryllium	0.13 mg/l
	Total Cadmium	Hardness Dependent
	Total Copper	Hardness Dependent
	Total Iron	1.0 mg/l
	Total Lead	Hardness Dependent
	Total Mercury	0.0014 mg/l
	Total Nickel	Hardness Dependent
	Total Selenium	0.005 mg/l
	Total Silver	Hardness Dependent
	Total Zinc	Hardness Dependent

Source: Multi-Sector General Permit for Storm water Discharges Associated with Industrial Activity (MSGP): Authorization to Discharge Under the national Pollutant Discharge Elimination System, p. 67 (Effective May 27, 2009). http://www.epa.gov/npdes/pubs/msgp2008_finalpermit.pdf

As shown in the table above, benchmark values for certain parameters are dependent on the hardness of receiving waters. Permittees must first measure the hardness of the receiving water and then refer to the appropriate water hardness range to determine the applicable benchmark value.

Table C-11 US Hardness Dependent Benchmarks for Subsector G2 (Discharge from Waste Rock and Overburden Piles)

Water Hardness Range	Cadmium (mg/l)	Copper (mg/l)	Lead (mg/l)	Nickel (mg/l)	Silver (mg/l)	Zinc (mg/l)
0-25 mg/l	0.0005	0.0038	0.014	0.15	0.0007	0.04
25-50 mg/l	0.0008	0.0056	0.023	0.2	0.0007	0.05
50-75 mg/l	0.0013	0.009	0.045	0.32	0.0017	0.08
75-100 mg/l	0.0018	0.0123	0.069	0.42	0.003	0.11
100-125 mg/l	0.0023	0.0156	0.095	0.52	0.0046	0.13
125-150 mg/l	0.0029	0.0189	0.122	0.61	0.0065	0.16
150-175 mg/l	0.0034	0.0221	0.151	0.71	0.0087	0.18
175-200 mg/l	0.0039	0.0253	0.182	0.8	0.0112	0.2
200-225 mg/l	0.0045	0.0285	0.213	0.89	0.0138	0.23
225-250 mg/l	0.005	0.0316	0.246	0.98	0.0168	0.25
250+ mg/l	0.0053	0.0332	0.262	1.02	0.0183	0.26

Source: Multi-Sector General Permit for Storm water Discharges Associated with Industrial Activity (MSGP): Authorization to Discharge Under the national Pollutant Discharge Elimination System, p. 67 (Effective May 27, 2009). http://www.epa.gov/npdes/pubs/msgp2008_finalpermit.pdf

3.3.1 Storm water Runoff Effluent Limit Monitoring Requirements

In addition to quarterly benchmark monitoring, US permitting standards require permittees to engage in annual monitoring for effluent limits based on sector-specific guidelines. Monitoring must be conducted on waste streams resulting from the particular industrial activity in question prior to commingling with other waste streams, even those covered under other areas of the permit. In addition to numerical effluent limits, the MSGP also includes technology-based effluent limits. For the metal mining sector, these technology-based limits include storm water diversions, capping, and treatment.

3.3.2 Additional Storm water Runoff Monitoring Requirements

For particular sectors or subsectors, the MSGP imposes additional monitoring requirements. For example, MSGP Part 8.G.8.3 mandates monitoring of additional parameters based on the type of ore being mined at a given site:

Table C-12 US Monitoring Requirements for Discharges from Waste Rock and Overburden Piles

Type of Ore Mined	Pollutants of Concern		
	Total Suspended Solids (TSS)	pH	Metals, Total
Tungsten Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Zinc (H)
Nickel Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Zinc (H)
Aluminum Ore	X	X	Iron
Mercury Ore	X	X	Nickel (H)
Iron Ore	X	X	Iron (Dissolved)
Platinum Ore			Cadmium, Copper (H), Mercury, Lead (H), Zinc (H)
Titanium Ore	X	X	Iron, Nickel (H), Zinc (H)
Vanadium Ore	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Zinc (H)
Molybdenum	X	X	Arsenic, Cadmium (H), Copper (H), Lead (H), Mercury, Zinc (H)
Uranium, Radium, and Vanadium Ore	X	X	Chemical Oxygen Demand, Arsenic, Radium (Dissolved and Total), Uranium, Zinc (H)

NOTE:
"X" indicated for TSS and/or pH means that permitees are required to monitor for those parameters.
"H" indicates that hardness must also be measured when this pollutant is measured.

Source: Multi-Sector General Permit for Storm water Discharges Associated with Industrial Activity (MSGP): Authorization to Discharge Under the national Pollutant Discharge Elimination System, p. 68 (Effective May 27, 2009). http://www.epa.gov/npdes/pubs/msgp2008_finalpermit.pdf

3.4. AIR EMISSION LIMITS FOR THE MINING SECTOR

The lack of air emissions standards for sources relevant to this guideline limits this section to benchmark standards from the U.S. EPA. The section addresses air emission limits for generators used to supply electricity for mining equipment and operations and emissions limits for smelting operations that may be co-located with a mine.

Table C-13 US Emission Limits for Compression Ignition Internal Combustion Generators (Displacement <10 Liters Per Cylinder)[23]

Maximum Engine Power	Model Year(s)	NMHC + NO_x	NMHC[24]	NO_x[24]	CO[24]	PM[24]
KW<8 (HP<11)	2008+					0.40 (0.30)
8≤KW<19 (11≤HP<25)	2008+					0.40 (0.30)
19≤KW<37 (25≤HP<50)	2008-2012					0.30 (0.22)
	2013+	4.7 (3.5)				0.03 (0.02)
37≤KW<56 (50≤HP<75)	2008-2012	4.7 (3.5)				0.30 (0.22)[25]
	2013+					0.03 (0.02)
56≤KW<75 (75≤HP<100)	2008-2011	4.7 (3.5)				
	2012-2013		0.19 (0.14)[26]	0.40 (0.30)[26]	5.0 (3.7)	0.02 (0.01)
	2014+		0.19 (0.14)	0.40 (0.30)		
75≤KW<130 (100≤HP<175)	2008-2011					
	2012-2013		0.19 (0.14)[26]	0.40 (0.30)[26]	5.0 (3.7)	0.02 (0.01)
	2014+		0.19 (0.14)	0.40 (0.30)		
130≤KW<560 (175≤HP<750)	2007-2010	4.0 (3.0)			3.5 (2.6)	0.20 (0.15)
	2011-2013		0.19 (0.14)[26]	0.40 (0.30)[26]		0.02 (0.01)
	2014+		0.19 (0.14)	0.40 (0.30)		
KW>560 (HP>750) (except generator sets)	2007-2010	6.4 (4.8)			3.5 (2.6)	0.20 (0.15)
	2011-2014		0.40 (0.30)	3.5 (2.6)		0.10 (0.075)
	2015+		0.19 (0.14)	3.5 (2.6)		0.04 (0.03)
Generator Sets 560<KW≤900 (750<HP≤1200)	2007-2010	6.4 (4.8)			3.5 (2.6)	0.20 (0.15)
	2011-2014		0.40 (0.30)	3.5 (2.6)		0.10 (0.075)
	2015+		0.19 (0.14)	0.67 (0.50)		0.03 (0.02)
Generator Sets KW>900 (HP>1200)	2007-2010	6.4 (4.8)			3.5 (2.6)	0.20 (0.15)
	2011-2014		0.40 (0.30)	0.67 (0.50)		0.10 (0.075)
	2015+		0.19 (0.14)			0.03 (0.02)

Source: Federal Register Vol. 71 No. 132 (July 11, 2006). http://www.epa.gov/ttn/atw/nsps/cinsps/fr11jy06.pdf.

NOTES to "US Emissions Limits for Compression Ignition Internal Combustion Generators (Displacement < 10 Liters Per Cylinder)":

16 All units are grams/kilowatt-hour (grams/horsepower-hour).

17 NMHC = Non-methane Hydrocarbons; NO_x= Nitrous Oxides; CO = Carbon Monoxide; PM = Particulate Matter

18 A manufacturer has the option of skipping the 0.30 g/KW-hr PM standard for all 37-56 KW (50-75 HP) engines. The 0.03 g/KW-hr standard would then take effect 1 year earlier for all 37-56 KW (50-75 HP) engines, in 2012. The Tier 3 standard (0.40 g/KW-hr) would be in effect until 2012.

19 50 percent of the engines produced have to meet the NMHC + NO_x , and 50 percent have to meet the separate NO_x and NMHC limits.

Table C-14 US Emissions Limits for Compression Ignition Internal Combustion Generators (Displacement >10 Liters and <30 Liters Per Cylinder; Model Year 2007 and Later)[27]

Engine Size (Liters per Cylinder), Rated Power	THC + NO_x[28]	CO[28]	PM[28]
5.0≤displacement<15.0, All Power Levels	7.8	5	0.27
15.0≤displacement<20.0, <3,300 KW	8.7	5	0.5
15.0≤displacement<20.0, ≥3,300 KW	9.8	5	0.5
20.0≤displacement<25.0, All Power Levels	9.8	5	0.5
25.0≤displacement<30.0, All Power Levels	11	5	0.5

Source: Federal Register Vol. 71 No. 132 (July 11, 2006).
http://www.epa.gov/ttn/atw/nsps/cinsps/fr11jy06.pdf.

NOTES to "US Emissions Limits for Compression Ignition Internal Combustion Generators (Displacement < 10 Liters Per Cylinder)":

20 All units are grams/kilowatt-hour.

21 THC + NO_x = Total Hydrocarbons + Nitrous Oxides; CO = Carbon Monoxide; PM = Particulate Matter.

Table C-15 US National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Metal Processing Facilities

	Primary Lead Smelters			Secondary Lead Smelters	
	Blast furnace, dross reverberatory furnace, or sintering machine	**Sintering machine, electric smelting furnace, or converter**	**Facility using sulfuric acid plant**	**Blast (cupola) or reverberatory furnace**	**Pot furnace**
Particulate Matter	50 mg/dscm (0.022 gr/dscf)			50 mg/dscm (0.022 gr/dscf)	
Sulfur Dioxide		0.065% by volume			
Visible Emissions	20% opacity		20% opacity	20% opacity	10% opacity

	Primary Copper Smelters		
	Any dryer	**Roaster, smelting furnace, or copper converter**	**Dryer or facility using sulfuric acid plant**
Particulate Matter	50 mg/dscm (0.022 gr/dscf)		
Sulfur Dioxide		0.065% by volume	
Visible Emissions			20% opacity

	Primary Zinc Smelters		
	Sintering machine	**Roaster**	**Sintering machine or facility using a sulfuric acid plant**
Particulate Matter	50 mg/dscm (0.022 gr/dscf)		
Sulfur Dioxide		0.065% by volume	
Visible Emissions			20% opacity

	Metallic Mineral Processing Plants	
	Any stack emissions	**Fugitive emissions**
Particulate Matter	0.05 g/dscm (0.02 g/dscm)	
Sulfur Dioxide		
Visible Emissions	7% opacity (unless a wet scrubbing emission control device is used)	10% opacity

Source: Code of Federal Regulations Title 40 Part 60 Subparts L (Secondary Lead Smelters, last amended Oct. 6. 1975), LL (Metallic Mineral Processing Plants, last amended Oct. 17, 2000), P (Primary Copper Smelters, last amended Oct. 17, 2000), Q (Primary Zinc Smelters, last amended Feb. 14, 1989), and R (Primary Lead Smelters, last amended Jan. 15, 1976).

3.5 MINING SECTOR SOLID WASTE

Numerical performance limits are unavailable for processing wastes from mining activities, and countries frequently rely upon relevant air or water standards to address them. Performance expectations for waste management typically are addressed in terms of management practices. Often, one must consider whether the wastes are solid, liquid or gas, the proposed means of storing, treating and disposing of the wastes, and the risks of release into the air or water media. In the U.S., the Mining

Waste Exclusion exempts 20 mineral processing wastes from regulation as hazardous wastes[22] (although they are still subject to regulation as nonhazardous wastes). These include:

1	Slag from primary copper processing
2	Slag from primary lead processing
3	Red and brown muds from bauxite refining
4	Phosphogypsum from phosphoric acid production
5	Slag from elemental phosphorous production
6	Gasifier ash from coal gasification
7	Process wastewater from coal gasification
8	Calcium sulfate wastewater treatment plant sludge from primary copper processings
9	Slag tailings from primary copper processings
10	Flurogypsum from hydrofluoric acid production
11	Process wastewater from hydrofluoric acid production
12	Air pollution control dust/sludge from iron blast furnaces
13	Iron blast furnace slag
14	Treated residue from roasting/leaching of chrome ore
15	Process wastewater from primary magnesium processing by the anhydrous process
16	Process wastewater from phosphoric acid production
17	Basic oxygen furnace and open hearth furnace air pollution control dust/sludge from carbon steel production
18	Basic oxygen furnace and open hearth furnace slag from carbon steel production
19	Chloride process waste solids from titanium tetrachloride production
20	Slag from primary zinc processing

Source: http://www.epa.gov/osw/nonhaz/industrial/special/mining
NOTES to "20 Mineral Processing Wastes Covered by the Mining Waste Exclusion (Exempt from Regulation under RCRA Subtitle C)":

22 All mineral processing wastes not specifically named are still subject to RCRA Subtitle C if they are characteristically hazardous.

4 INTERNATIONAL TREATIES AND AGREEMENTS

CAFTA DR countries have ratified and/or signed a number of international treaties and agreements which provide commitments to adopting and implementing a range of environmental protection regimes. Most do not confer specific quantitative benchmarks for performance and so are not summarized in this Appendix. However, for convenience they are listed below as of the date of publication.

Table C-16 Multilateral Environmental Agreements Ratified (R) or Signed (S) by CAFTA-DR countries	Costa Rica	Dominican Republic	El Salvador	Guatemala	Honduras	Nicaragua
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal **into force -** 5 May 1992	R	R	R	R	R	R
Convention on Biological Diversity- abbreviated as Biodiversity **entered into force –** 29 December 1993	R	R	R	R	R	R
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar) **into force -** 21 December 1975	R	R	R	R	R	R
Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES) **into force -** 1 July 1975	R	R	R	R	R	R
Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter (London Convention) **into force -** 30 August 1975	R	R		R	R	
Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques-- **into force** -5 October 1978	R			R		R
Kyoto Protocol to the United Nations Framework Convention on Climate Change- **into force -** 23 February 2005	R	R	R	R	R	R
Montreal Protocol on Substances That Deplete the Ozone Layer- **into force -** 1 January 1989	R	R	R	R	R	R
International Convention for the Regulation of Whaling **in force -** 10 November 1948	R			R		R
International Tropical Timber Agreement, 1994 **into force -** 1 January 1997				R	R	
Protocol of 1978 Relating to the International Convention for the Prevention of Pollution From Ships, 1973 (MARPOL) **into force -** 2 October 1983		R		R	R	R
United Nations Convention on the Law of the Sea (LOS) **into force -** 16 November 1994	R	S	S	R	R	R
United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa **into force -** 26 December 1996	R	R	R	R	R	R
United Nations Framework Convention on Climate Change **into force -** 21 March 1994	R	R	R	R	R	R

https://www.cia.gov/library/publications/the-world-factbook/appendix/appendix-c.html

5 MINING SECTOR WEBSITE REFERENCES

Canada: Environment Canada

· The New Metal Mining Effluent Regulations
www.environment-canada.ca/nopp/docs/regs/mmer/EN/index.cfm

World Bank Group / International Finance Corporation

·Environmental, Health and Safety Guidelines for Mining
www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$File/Final+-+Mining.pdf

United States Environmental Protection Agency

· Compliance Assistance for the Minerals/Mining/Processing Sector
www.epa.gov/compliance/assistance/sectors/mineralsmining.html

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APPENDIX D. EROSION AND SEDIMENTATION

EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska January 2003
Appendix H: Erosion and Sedimentation

http://www.epa.gov/cgibin/epalink?logname=allsearch&referrer=mining|11|All&target=http://yosemite.epa.gov/R10/WATER.NSF/840a5de5d0a8d1418825650f00715a27/e4ba15715e97ef2188256d2c00783a8e/$FILE/Maintext.pdf

1 GOALS AND PURPOSE OF THE APPENDIX

Baseline knowledge of soil erosion and the subsequent transport and deposition of eroded sediment into streams and other water bodies is essential to mine planning and operation. Accurate measurement of natural erosion and erosion from disturbed areas is important to develop control practices. Significant environmental impacts, such as the irretrievable loss of soil, or the degradation of aquatic life from the sedimentation of streams, lakes, wetlands, or marine estuaries, can be minimized or prevented by employing control practices. The measurement and prediction of the amounts of erosion and sedimentation is inherently tied to the measurement and prediction of site hydrologic variables such as precipitation, runoff, and stream flow. An outline and comparison of methods, analytical procedures, and modeling for the characterization and measurement of site hydrology is presented in Appendix A*, Hydrology.* The goal of this appendix is to outline the rationale and methods to characterize and monitor soil erosion and sedimentation. This appendix also outlines and discusses the design and effectiveness of control practices to minimize impacts to water quality and aquatic resources. This appendix includes reference sections of both cited literature and other relevant references. A reference by Barfield et al. (1981) provides an excellent compendium of both hydrologic methods, as well as methods to measure erosion and to design erosion control structures at mines. The reader is referred to this source for a detailed compendium of methods to measure erosion and design control measures to mitigate erosion and sedimentation at mines.

2 TYPES OF EROSION AND SEDIMENT TRANSPORT

Erosion is a natural geologic process that is easily induced and accelerated by man's activities. Mining activities can require the disturbance of large areas of ground and require large-scale earth moving activities which expose large amounts of soil to erosive forces. Operations can be planned, however, to minimize the amount of soil exposed and to reduce or prevent adverse effects on the streams or other water bodies from sedimentation. Soil erosion can be defined as the detachment, transport, and deposition of soil particles. Detachment is the dislodging of soil particles from aggregates or soil peds from either rain drop impact or from the shearing forces of water or air flowing over the surface. Of these, rain drop impact is the primary force causing detachment, while the flow of water or air over the surface is the primary mechanism for transport. Rain drop splash can also be a cause of soil transport at a micro-scale (Maclean, 1997). Transport by runoff across the surface, therefore, does not generally occur until the rainfall rate exceeds the infiltration capacity of the soil. Once runoff occurs, the quantity and size of soil particles transported is a function of the velocity of the flow (Barfield et al., 1981). Transport capacity decreases with decreasing velocity causing deposition. As velocity decreases, the largst particles and aggregates are deposited first with smaller particles being carried down slope. Deposition, therefore, usually results in the size and density sorting of eroded soil particles, with increasingly smaller sized particles being deposited down slope or down stream. The deposition of detached soil in streams is often referred to as sedimentation.

2.1 INTERRILL AND RILL EROSION

Erosion occurs on disturbed or exposed areas by either interill or rill erosion. Interill erosion is sometimes referred to as sheet erosion. The primary erosive force in interrill areas is rain drop impact, where increasing detachment and erosion rates occur with increasing drop size and drop velocity. Rills are small channels which form on the surface as a result of increasing amounts of runoff. By definition, rills can generally be removed by ordinary tillage equipment or from light grading. Larger channels are considered gullies (see Section 2.2). Detachment occurs in rills by the shear forces of flowing water in the rill. The number of rills and the amount of rill erosion increases as the slope or the amount of surface runoff increases. Interill erosion is the dominant process on shallower slopes. Surface roughness and soil cohesive properties are the primary factors in controlling the degree of interill and rill erosion that occurs from an exposed area. The amount of vegetation cover is the primary factor affecting surface roughness. Vegetation decreases the velocity of runoff across the surface and protects the soil from rain drop impact. Other measures can be employed to increase surface roughness and minimize erosion. These measures are discussed in Section 6.0, Best Management Practices.

2.2 GULLY EROSION

Gullies can be either continuous or discontinuous channels that flow in response to runoff events. By definition, gullies differ from rills in that they cannot be removed by ordinary tillage or grading practices. Gullies may be a temporary feature by being erosively active, or in a state of "healing" where annual deposition within the gully is greater than the detachment and transport of eroded materials. Healing is usually caused by changes in land use that reduce the velocity of surface runoff, such as applying reclamation measures to increase surface roughness and promote infiltration. The physical process of erosion in gullies is essentially the same as that described for rills. Erosion in gullies occurs primarily from the shear forces of flowing water. Foster (1985), however, indicated that the amount of erosion from gullies is usually less than the amount that occurs from rills. This is because the amount of erodible particles are quickly removed from the gully channel, where rills are established on an actively eroding surface. Therefore, after initial formation, gullies usually serve as a principal transport mechanism for entrained soils. Gullies can form quickly during extreme events on denuded land and can rapidly expand both up and down slope (Maclean, 1997). In these cases, gullies temporarily serve as large sources of eroded soil and sedimentation to water bodies. Uncontrolled runoff and gully formation can be a large source of transported sediment at mine sites.

2.3 STREAM CHANNEL EROSION

tream channels differ from gullies in that they are permanent channels that transport surface waters. Stream channels can be perennial, ephemeral or intermittent. In stable stream channels, erosion and deposition is controlled by the transport capacity of a given stream flow, which is, in turn, governed by the velocity of flow and by local variations in shear stress in the channel. Detachment and entrainment of soil particles will occur along the stream bed and sides of a channel when the transport capacity is greater than the sediment load being transported. Deposition occurs when the transport capacity is less than the sediment load being transported. As described in Section 2.0 above, deposition occurs from the largest to the smallest particles as velocity and transport capacity decrease. Potential impacts from mine related activities on channel erosion processes are discussed in Section 3.0.

2.4 MASS WASTING, LANDSLIDES AND DEBRIS FLOWS

Landslides and slope failures that create large areas of mass wasting can occur naturally or can be induced as a result of man's activities. The potential for landslides to occur generally increases in steep areas containing unstable soils or where the bedrock has unfavorable dip directions. Landslides and slope failures occur naturally over time, usually during extreme precipitation events when saturation reduces the shear strength of the soils or rock. Slope failures and landslides can also be induced by construction activities that create cuts or slopes where soils or rock are left exposed at steep, unstable angles.

Landslides can expose large areas of soil and debris that are subject to the erosion and sedimentation processes discussed above. Landslides can block stream channels with soil and rock debris, causing ponding and eventual flooding. The eventual failure of an unstable blockage can result in flood flows that entrain large quantities of soil and rock debris. Scouring of the existing channel below the landslide also results from the high flood flows. Additional debris loading can occur from mass wasting along the side slopes, adding more sediment and debris loads to the flood flow.

Effects from avalanches can be similar to those of landslides. Avalanches can remove vegetation, increasing the erosion potential of exposed soils and rock. Debris and snow from an avalanche can temporarily block stream channels, creating floods, channel scour, and mass wasting along side slopes.

Landslides, slope failures, and avalanches can create large impacts to aquatic resources. Increased erosion and resulting sedimentation within a watershed can impact spawning gravels, egg survival and emergence of frye, as well as degrade benthic food sources. Flooding can create high velocity flows, scour stream banks and destroy gravel substrates either by scour or by burial beneath sediment. Cover created by large woody debris and stable banks also can be destroyed, which impacts rearing and resting habitat for fishes.

3 MINING-RELATED SOURCES OF EROSION AND SEDIMENTATION

Increased potentials for erosion and sedimentation at mines are related to mine construction and facility location. Tailings dams, waste rock and spent ore storage piles, leach facilities, or other earthen structures are all potential sources of sedimentation to streams. Road construction, logging, and clearing of areas for buildings, mills, and process facilities can expose soils and increase the amount of surface runoff that reaches streams and other surface water bodies. These activities increase the potential for rill and interill erosion and can increase peak stream flows, increasing the potential for channel erosion. Unusually high peak flows can erode stream banks, widen primary flow channels, erode bed materials, deepen and straighten stream channels, and alter channel grade (slope). In turn, these changes in stream morphology can degrade aquatic habitats. Channelization can increase flow velocities in a stream reach, potentially affecting fish passage to upstream reaches during moderate to high stream flows. Poorly designed stream diversions can also create channelization effects and alter flow velocities in a stream. Increased erosion upstream and the resulting sedimentation downstream can impact spawning gravels, egg survival and emergence of frye, as well as degrade benthic food sources. More detail on these potential impacts is given in *Appendix A, Hydrology.* Tailings dams and large embankments can also fail, creating impacts similar to those discussed in Section 2.4 above for landslides and debris flows.

4 METHODS TO MEASURE AND PREDICT EROSION AND SEDIMENTATION

Most methods to measure, predict and control erosion and sedimentation have been developed by the agriculture industry.These methods concentrate on predicting gross erosion and sediment yield from disturbed areas or areas under tillage. This is advantageous for evaluating and predicting impacts that result from mining because tillage agriculture and mining have several similarities (Barfield et al., 1981). Both industries can disturb and expose large areas of ground and both must apply practices to limit or eliminate soil-loss and sedimentation impact. It should be noted, however, that many mine sites are often located on steeper slopes and in more diverse topography than agricultural lands. Methods developed for the measurement of erosion and sedimentation from agricultural lands are generally not adapted or tested for use on steep slopes. For this reason, appropriate conservatism should be applied when choosing analytical methods and in evaluating predictive results.

Most methods to measure or predict erosion and sedimentation are designed to predict either: (1) "gross erosion", (2) "sediment yield", (3) a "sediment delivery ratio", or (4) sediment loading in streams. Gross erosion is defined as the total estimated amount of sediment that is produced from rill and interill erosion in an area (Barfield et al., 1981). The sediment yield from an area or watershed is the gross erosion, plus the additional erosion that is contributed from gullies and stream channels, minus the amount of deposition. The amount of deposition that occurs between the watershed and a down-gradient point of reference is quantified using a sediment delivery ratio. A sediment delivery ratio can be quantitatively defined as the ratio of sediment yield to gross erosion: where D is the sediment delivery ratio, Y is the sediment yield, and A is the gross erosion (Barfield et al., 1981).

Few methods have been developed to specifically predict gross erosion or sediment yield from undisturbed landscapes and watersheds. Methods for field measurement, as well as methods to analytically predict or model sediment yield are commonly employed on both disturbed and on undisturbed areas. For this reason, field and analytical methods that can be used to measure gross erosion or sediment yield on disturbed and undisturbed areas are outlined together in this appendix. This section summarizes methods to measure or predict gross erosion, methods to measure or predict sediment yield, including modeling, and methods to measure sediment loads and deposition in streams.

4.1 GROSS EROSION

4.1.1.Field Measurements

Few field methods are usually employed to measure the amount of gross erosion which actually occurs from a small plot or watershed. A method commonly used, however, is to use erosion pins.Using this method, small pins or stakes are put into the ground to a depth that will prevent disturbance. The elevation of the top of the pin is surveyed and referenced to a permanent elevation. The difference between the top of the pin and the ground elevation below the pin is periodically surveyed to determine minute changes in elevation. The difference in measured elevation between sampling events reflects the amount of rill and interill erosion that has occurred at that point. Gross erosion that occurs from a sample plot can be estimated using measurements from several pins. Repeated measurements of water and sediment collected in permanently installed hill slope troughs can also be used to detect soil movement and storage over time.

Tracers have also been used to detect and measure actual soil movement on small plots. Kachanoski et al. (1992) describe the use of Cesium-137 (137Cs) to detect soil movement and soil loss in a complex landscape and to monitor the down-slope movement of soils that occur from tillage. 137Cs occurs in soils from atmospheric deposition (fall out) that occurred from aboveground nuclear testing conducted in the 1950s and 1960s. 137Cs tightly binds to soils, is essentially insoluble and does not leach, and is not subject to significant uptake by plants. Monitoring gains or losses of 137Cs at permanent points can be used to detect movement of soil.Other inert tracers can be used similarly.

The above field methods are commonly employed for research purposes where actual land treatment applications or practices are compared. They are often employed to aid model validation or to help calibrate modeled soil losses from a specific area. While these methods can be used to detect soil movement and estimate gross erosion on small plots, they may not be applicable at mine sites because they are not suitable for large areas, and they do not predict sediment yield or sedimentation of streams or other water bodies.

4.1.2.The Universal Soil Loss Equation.

The most commonly used procedure to predict gross erosion is the Universal Soil Loss Equation (USLE), in its original form. The USLE was proposed by Wischmeier and Smith (1965) based on a relationship known as the Musgrave equation (Musgrave, 1947). The USLE predicts gross erosion produced by rill and interrill erosion from a field sized area. Several authors have proposed modifications to the USLE to account for deposition so the model can also be used to predict sediment yield. These modifications will be discussed in Section 4.2 with methods to measure and predict sediment yield. The USLE predicts gross erosion by the following:

$$\mathbf{A = R * K * LS * C * P}$$

Where:
A is computed soil loss per unit of area (tons/acre);
R is a rainfall factor which incorporates rainfall energy and runoff;
K is soil erodibility;
LS is a dimensionless length slope factor to account for variations in length and degree of slope;
C is a cover factor to account for the effects of vegetation in reducing erosion; and
P is a conservation practice factor.

A detailed discussion of how to calculate, incorporate, and use each of these factors is provided by Barfield et al. (1981) and Goldman et al. (1986). The USLE can be used to predict gross erosion from anarea for average annual, average monthly, average storm, and annual return period, or for asingle storm return period, depending on how R is calculated. Use of the USLE, without modification, at mine sites has several disadvantages. The calculation does not account for erosion from gullies, or stream channels, or take into account deposition. It was primarily designed to predict soil-loss from small fields and should not be used to predict sediment levels in rivers at the drainage basin level. For most applications at mine sites, the unmodified USLE described above would not provide useful estimates because most impact analyses require knowledge of deposition and actual sediment yield from watersheds or disturbed areas, and calculations of sediment transport in gullies and channels.

Consequently, this method is not recommended, except for calculations of potential soil-loss from a small disturbed area to aid in the application of best management practices (BMPs) and the design of other area-specific controls.

4.2 SEDIMENT YIELD

Most methods and mathematical models to measure or predict erosion are designed to predict sediment yield from an area or watershed. Many of the methods and models use the USLE, described in Section 4.1.2, however, they incorporate techniques to evaluate and route erosion from gullies and channels and estimate deposition, either on the land surface or in streams. The following discussion provides a brief review of commonly used methods to measure sediment yield and presents a review of mathematical models which have been used to predict sediment yield on an areal or watershed basis.

4.2.1. Modified and Revised Universal Soil Loss Equation

There have been several proposed modifications to the USLE that allow for more accurate predictions of parameters and erosion. For purposes of baseline characterization and prediction of sedimentation at mine sites, two modifications are applicable. The Modified Universal Soil Loss Equation (MUSLE) and the Revised Universal Soil Loss Equation (RUSLE).In the standard USLE model, the rainfall energy and runoff factor (R) and the length-slope factor (LS) do not account for deposition or assume that it does not occur until the end of the length of the ground segment being analyzed. Williams (1975) proposed that the R factor be replaced with several other terms to allow the equation to better account for deposition. This modification (MUSLE) can then be used to estimate the sediment yield from an area or from atersheds. The MUSLE equation is calculated by:

$$\mathbf{Y = 95(Q * qpi)0.56 * K * LS * P}$$

Where:Y is the single storm sediment yield;Q is the runoff volume, qpi is the peak discharge, andK, LS, and P are the same terms as for the USLE except that they represent weighted averagesfor these parameters, calculated from different areas of the watershed. The LS factor is alsocalculated differently than in the USLE, depending on the slope being analyzed (Williams, 1975).

The RUSLE described by McCool et al. (1987) provides a further revision of the LS factor and modifies the model to be more applicable on steep slopes, greater than 10 percent. The application of the MUSLE and the RUSLE to large, heterogeneous watersheds, such as those that occur at mine sites, requires that sediment yield calculations be analyzed for each subwatershed (see Williams (1975) and Barfield et al. (1981) for detailed discussions). The analysis requires that large, heterogeneous watersheds be divided into several subwatersheds with relatively homogeneous hydrologic characteristics and soil types. Consequently, particle size distribution (i.e., texture analysis) must be measured for the soils occurring in each subwatershed. The analysis also requires the calculation of a weighted runoff energy term (Q* qpi) that is computed as a weighted average of the subwatersheds. From particle size distribution data, the median (D50) particle diameter is used to calculate the sediment yield that would exit each subwatershed. The weighed runoff energy term is used to route sediments to the mouth ofthe large watershed or at some point of analysis.

4.3 SUSPENDED LOAD AND SEDIMENTATION

The evaluation of water quality and impacts to aquatic resources is a primary concern at mine sites. Without mitigation and control measures, mining can disturb large areas of ground, causing accelerated erosion and sedimentation and potentially causing adverse impacts to aquatic resources. The measurement of sediment load in streams is a primary tool to evaluate the effectiveness of erosion control measures and potential impacts to water quality and aquatic life. Typically, it is a required component for monitoring compliance with NPDES permits. As discussed in Section 2.3, the amount of sediment load being carried at any given time in a stream depends on the transport capacity, which is primarily related to the stream flow velocity. As transport capacity increases, the amount and particle sizes of suspended sediment increases. Transport capacity decreases with decreasing flow velocity, causing deposition and sorting of materials. The transport and deposition of sediments within a stream, therefore, dependent on storm frequency and the velocity of peak flows. In many cases, high flow events are periodically required to entrain and transport sediments that were deposited during low flow periods when low peak velocities caused sediment deposition. These are known as channel maintenance flows. Geomorphologically, a stable channel is one that over time, transport sediments with no net increase in deposition and without channel erosion.

The Equal Transient Rate (ETR) and Equal Width Increment (EWI) methods are commonly used field methods to sample suspended sediments during stream flow (USGS, 1960). Using these methods, several water samples are taken along cross-sectional transects (i.e., perpendicular to flow direction). Samples along the cross section are taken by lowering a sample bottle through the stream at a rate dependent on the flow velocity. The total mass of suspended sediment and its particle size distribution are measured for each sample. Automatic sediment samplers are also available that collect stream samples at scheduled times that are determined by the user. These data are used to develop a sediment rating curve or a sedigraph that defines the relationship between stream flow discharge (Qw) and the mass of suspended sediment at a given sampling station. After a sediment rating curve has been developed, stream flow measurements can be used to estimate sediment discharge at a given station. Sediment rating curves and sedigraphs can be extremely useful for monitoring the effectiveness of control practices applied to minimize erosion and sediment yield from mine sites. The development of sediment rating curves, however, requires sampling across a large range of flows and at different seasons of the year. These relationships can be continuously recalibrated and refined as the size of the sampled data base increases.

Net increases in sediment deposition in streams and other water bodies are measured using substrate core samples at various times of the year. Core samples, taken using a variety of substrate and coring equipment, are analyzed for net changes in particle size distribution over time. It is important for water quality analyses at mines, that sampling programs to monitor sedimentation in stream beds incorporate comparisons with stream flow events. Regular sampling throughout the year is required to determine if net deposition of sediments is occurring in a stream over time. Sediments are naturally deposited during seasonal low flow periods and are naturally entrained and transported during high flow periods. These processes make impact analysis by sedimentation extremely difficult to monitor.

In addition to the above analyses, characterization of pre-mining stream morphology from drainages potentially affected by a mining operation are often necessary to determine potential impacts caused by changes in flow regime and from sedimentation. These analyses may include photo documentation of streams and riparian vegetation, determining geomorphological classifications of streams using the Rosgen (1994) method, and measurements to define channel cross sections, width to depth ratios, longitudinal profiles, sinuosity, and pool/riffle ratios. These data would support studies conducted to characterize site hydrology and aquatic resources.

4.4 SOFTWARE AND WATERSHED MODELS FOR PREDICTION OF SEDIMENT YIELD

Characterization of mine sites requires the accurate calculation of sediment yield on a large watershed basis. To characterize baseline conditions at mine sites and to predict potential adverse impacts from sedimentation requires adequate spatial and areal characterization of gross erosion and sediment yield. Several analytical software programs are available to predict sediment yield and sediment transport in large watersheds. Some of these can be incorporated into GIS applications to provide spatial evaluation of erosion potential and sediment yield for one or more watersheds.

The MUSLE and RUSLE, applications described in Section 4.2.1 could be used to characterize baseline conditions of sediment yield and to evaluate potential changes in expected sediment yield that would result from development of mine facilities. Most software, watershed models, and GIS applications that are commonly used to predict erosion and sediment yield apply either the USLE, MUSLE, or RUSLE algorithms. A brief description of analytical software used for watershed analysis and for the evaluation of sediment yield is provided in Section 4.4.2. Particular emphasis is given to those methods that are commonly used in mine settings.

The following questions, modified from Maclean (1997), can be used to determine the type and level of modeling effort needed and software required to evaluate erosion and sedimentation at mine sites:

- What are the basic assumptions and method(s) applied in the model?
- Is the output suitable to make the evaluations and analyses required and is the accuracy sufficient for characterization, impact analysis, and detection monitoring?
- What are the temporal and spatial scales of the required analysis?
- What are the input data requirements of the software or model?
- What data are needed for model calibration and verification?
- Are the required data available and are they at the correct scale?
- What input data are the most important (i.e., have the most sensitivity)?
- Can surrogates be used for missing data without compromising an accurate analysis?
- If the model uses empirical (i.e., statistical) relationships, under what conditions were those formed?

Answering these questions will help the mining hydrologist to select appropriate techniques and models and to design adequate sampling programs to obtain the required input data. As previously discussed, to adequately evaluate and monitor impacts at mine sites typically require temporal and spatial analysis of a large watershed. This necessitates the design of a sampling programs that will provide adequate data on a watershed basis. Monitoring programs to evaluate erosion and sedimentation should be coordinated with baseline hydrological and water quality characterization studies. The reader is referred to Appendix A, *Hydrology* and Appendix B, *Receiving Waters* for related discussions.

4.4.1. Development of a Conceptual Site Model.

A conceptual site model can be used to expedite an evaluation of the questions and parameters discussed in Section 4.3. A conceptual site model is a depiction, descriptive, or pictorial, of subwatersheds, soil-types, slopes, stream channels and any erosional features. Such a model should be developed in conjunction with studies to characterize baseline soil and vegetation types and surface water bodies. The purpose of building or developing a conceptual model of a site is to show important interrelationships that need to be evaluated, studied, or modeled. Programs to analyze impacts and monitor site conditions can then be developed. The conceptual model should be complex enough to adequately depict system behavior and meet study objectives, but sufficiently simple to allow timely and meaningful development of field sampling programs and predictive models.

4.4.2. Analytical Software and Models.

AGNPS - Agricultural Non-Point Source Pollution Model
AGNPS is a distributed river basin model which combines elements of several other models to predict erosion, runoff, and sediment and chemical transport. The model incorporates the USLE to predict gross erosion from defined grids within a the river basin. Runoff and overland flow is calculated using Natural Resource Conservation Service (NRCS [Soil Conservation Service]) procedures (see Appendix A, Hydrology). Transport and deposition relationships are used to determine sediment yields and route sediment through the modeled basin. The program is designed for large basins and requires very detailed site characterization data for input. The level of accuracy necessary for the prediction of sediment yield and transport at mine sites would require detailed field sampling to provide input data. The model has the inherent problems associated with the USLE, described in Section 4.1.2, and problems associated with the SCS hydrologic methods to predict runoff (See Appendix A , Hydrology). The assumptions of the USLE and the SCS methods should be completely understood when using this model for predictive purposes. A review of this model is provided by Jakubauskas (1992).

ANSWRS - Areal Non-Point Source Watershed Response Simulation Model
ANSWRS is a distributed river basin model that is similar to the AGNPS model. The model uses the USLE to predict the upland component for gross erosion and a set of steady state equations to simulate sediment transport through the basin. A review of this model is provided by Jakubauskas (1992). Both the ANSWRS and AGNPS models are designed to evaluate erosion and plan control strategies on areas with intense cultivation.

WEPP - Water Erosion Prediction Project Hydrology Model
WEPP is designed to use soil physical properties and meteorological and vegetation data to simulate surface runoff, soil evaporation, plant transpiration, unsaturated flow, and surface and subsurface drainage. The model uses the Green and Ampt infiltration equation to estimate the rate and volume of storm excess precipitation. Excess precipitation is routed down slope to estimate the overland flow hydrograph using the kinematic wave method. In WEPP, surface runoff is used to calculate rill erosion and runoff sediment transport capacity. The infiltration equation is linked with the evapotranspiration, drainage, and percolation components to maintain a continuous daily water balance for a watershed.

GSTARS - Generalized Stream Tube Model for Alluvial River Simulation
GSTARS is a generalized semi-two dimensional water and sediment routing model. The model is capable of computing alluvial scour/deposition through subcritical, supercritical, and a combination of both flow conditions involving hydraulic jumps. The program can be used as a fixed-bed or a moveable bed model to route water and sediment through alluvial channels. A one-dimensional model can be created with the selection of a single stream tube. By selection of multiple stream tubes, changes in cross section geometries in the lateral direction can be simulated.

HEC-6 - Scour and Deposition Model

HEC-6 is designed to evaluate long-term river and reservoir sedimentation behavior. The program simulates the transportation of sediment in a stream and can determine both the volume and location of sediment deposits. It can analyze in-stream dredging operations, shallow reservoirs, and scour and deposition effects in streams and rivers, in addition to the fall and rise of movable bed material during several flow cycles. The program is primarily designed to analyze sediment transport and geomorphologic effects in rivers and streams. It is not intended for use in analyzing gross erosion or sediment yield from watersheds.

Sedimot-II - Hydrology and Sedimentology Model 1

Sedimot-II is designed to generate and route hydrographs and sediment loads through multiple subareas, reaches and reservoirs. It can also be used to evaluate the effectiveness of sediment detention ponds and grass filters. The program can predict peak sediment concentration from a flow event, trap efficiency of a sediment retention basin, sediment load discharge, peak effluent sediment concentration, and peak effluent settleable concentration.

SEDCAD+ 2

SEDCAD+ provides computer-aided design (CAD) capabilities for the design and evaluation of storm water, erosion, and sediment control management practices. The software combines hydrological and sediment yield modeling with CAD capabilities to design and evaluate the performance of sediment detention basins, channels, grass filters, porous rock check dams, culverts and plunge pools. In addition, the program provides determinations of land volumes, areas, and cut/fill volumes. The program uses the MUSLE and RUSLE algorithms to calculate sediment yield from watersheds. The software has used as a part of the Office of Surface Mining's Technical Information Processing System (TIPS). TIPS is a series of
integrated programs to provide automated software to support a full range of engineering, hydrological, and scientific applications required for permitting.

PONDPACK 1

PONDPACK is designed to provide CAD capabilities for the design and evaluation of storm water detention ponds. The program provides analysis of detention storage requirements, computes a volume rating table for pond configuration, routes hydrographs for different return frequencies, and provides routing data for inflow and outflow hydrographs for comparing alternative pond designs.

4.4.3. Application of Remote Sensing and Geographical Information Systems

Recent research has evaluated the use of Geographical Information Systems (GIS) and data obtained from satellites in predictions of large-scale erosion potential. Example studies are provided by MacLean (1997) and DeRoo et al. (1989); other references are provided at the end of this appendix. In general, GIS systems can be used to provide spatial data for soil-types, vegetation cover types, aspect, slope, slope-lengths, and other variables that are required inputs for large-scale watershed models. These data may bes incorporated or estimated using remotely sensed data obtained from SPOT or LANDSAT imagery. Modeled data can also be presented and analyzed using a GIS system as demonstrated by the studies referenced above, which incorporated spatial data into large-scale, river basin models that evaluated erosion potential and prediction using the USLE. In general, these studies showed that a GIS system could be used to manage, provide and evaluate large amounts of spatial data in conjunction with erosion modeling. These studies, however, indicated that model accuracy and validation were deficient because specific site data were not available or had to be assumed. DeRoo et al. (1989) suggested that model accuracy is extremely sensitive to the "lack of detailed" input data such as infiltration capacities, antecedent soil moisture, and rainfall intensity information for specific sites. MacLean (1997) indicated that confidence in the results generated using GIS was low. These studies indicate that large, spatially integrated systems could be used at mine sites for baseline characterization and analysis of impacts. However, mining hydrologists and other scientists must be aware that specific information regarding soil-types, soil particle size analysis, vegetation types, slopes, slope-lengths, and sub-basin hydrology are required to produce accurate erosion and sedimentation analyses. Caution should be used when integrating spatial data bases with predictive modeling in cases where site-specific data are inadequate.

5 REPRESENTATIVENESS OF DATA

The representativeness of data and statistical concepts related to sampling and the development of data quality objectives are discussed in detail in *Appendix A, Hydrology.* In general, the principles associated with sample adequacy, statistical techniques and the development of Quality Assurance programs for erosion and sedimentation are similar to those associated with hydrological measurements. A detailed discussion of these concepts is not repeated herein; the reader is referred to Appendix A for a discussion of statistical techniques and important parameters to consider in developing adequate sampling designs. Several concepts related to the measurement of erosion and sedimentation should be considered when developing Data Quality Objectives and sampling programs. The following points provide specific concepts which should be applied or noted in developing programs for monitoringerosion and sedimentation at mine sites:

- The processes of gross erosion, sediment yield, and sediment deposition in streams depends on the frequency and probability of hydrologic events, both seasonally and on an event basis. The amounts of sediment erosion, transport, and deposition vary seasonally and in response to individual precipitation-runoff events of different frequencies. For this reason characterization and monitoring programs at mine sites must be designed to evaluate erosion and sediment yields with respect to the frequency of storm events, as well as account for both seasonal and annual climatic variations. Similarly, characterization and monitoring programs to evaluate suspended loads in streams must take into account stream discharge measurements. Impact analysis can only be conducted if adequate relationships are developed between precipitation and runoff, stream flow, and sediment load.
- The effectiveness and accuracy with which mathematical models and empirical equations predict gross erosion, sediment yield, and sediment deposition depends on the quality of site-specific data collected to characterize soils, vegetation types, slopes, slope-lengths, and other watershed or subwatershed parameters. Of specific importance is that the samples collected to determine the particle size distributions (i.e., texture) of each soil type provide a statistically adequate population. Adequate sampling to characterize vegetative cover and other surface roughness factors controlling soil detachment and water flow velocities is also essential.
- The use of spatial data and GIS analyses should be encouraged to evaluate and predict potential impacts on a watershed basis. These analyses can be used to develop maps and provide spatial analyses of areas susceptible to erosion. As discussed in Section 4.4.3, however, the accurate prediction of erosion and sedimentation on a large-scale depends on having adequately characterized site specific data.

6 METHODS TO MITIGATE EROSION AND SEDIMENTATION

Best Management Practices (BMPs) are schedules of activities, prohibitions of practices, maintenance procedures, and other management practices that effectively and economically control problems without disturbing the quality of the environment. Erosion and sedimentation may be effectively controlled by employing a system of BMPs that target each stage of the erosion process. Fundamentally, the approach involves minimizing the potential sources of sediment from the outset. In order to accomplish this, BMPs are designed to minimize the extent and duration of land disturbance and to protect soil surfaces once they are exposed. BMPs are also designed to control the amount and velocity of runoff and its ability to carry sediment by diverting incoming flows and impeding internally generated flows. BMPs also include the use of sediment-capturing devices to retain sediment on the project site. The types of BMPs discussed in this appendix include surface stabilization procedures, runoff control procedures and conveyance measures, outlet protection procedures, sediment traps and barriers, and stream protection procedures. Table H-1 provides an outline, by categorical type, that are used at minesites. Sections 6.1.1 through 6.1.5 provide brief descriptions of these BMPs. Many of the BMPs are complementary and are used together as part of an erosion control program. An important BMP used at mine sites to capture, manage and control sedimentation is the use of *Sediment Detention Basins.* Section 6.1.6 describes detention basins and discusses important design parameters for these basins at mine sites.

Table H-1. Mining BMPs for Control of Erosion and Sedimentation

Category	***Best Management Practice***
Surface Stabilization	Dust control Mulching Riprap Sodding Surface roughening Temporary gravel construction access Temporary and permanent seeding Topsoiling
Runoff Control and Conveyance Measures	Grass-lined channel Hardened channel Paved flume (chute) Runoff diversion Temporary slope drain
Outlet Protection	Level spreader Outlet stabilization structure Sediment Traps and Barriers Brush barrier Check dam Grade stabilization structure Sediment basin/rock dam Sediment trap Temporary block and gravel drop inlet protection Temporary fabric drop inlet protection Temporary sod drop inlet protection Vegetated filter strip
Stream Protection	Check dam Grade stabilization structure Streambank stabilization Temporary stream crossing
Source: NCSU Water Quality Group (1998)	

6.1 BEST MANAGEMENT PRACTICES (BMPS) CATEGORIES

The following discussion of Best Management Practices is adapted from NCSU Water Quality Group (1998).

6.1.1. Surface Stabilization Measures

Dust Controlis the manipulation of construction areas through specific measures to prevent soil loss as dust. Effective control measures include watering, mulching, sprigging, or applying geotextile materials. These measures are designed to minimize the contamination of runoff water from air born dust. These practices are especially effective in regions with a dry climate or in drier seasons.

Mulchingis the protection of vegetative surfaces with a blanket of plant residue or synthetic material applied to the soil surface to minimize raindrop impact energy, increase surface roughness and reduce the velocity of runoff. These practices are designed to foster vegetative establishment, reduce evaporation, insulate the soil, and suppress weed growth. As well as providing immediate protection from environmental hazards, mulch is used as a matrix for spreading plant seeds.

Riprapis a retention wall of graded stone underlain with a filter blanket of gravel, sand and gravel, or synthetic material designed to protect and stabilize areas which are prone to erosion, seepage, or poor soil structure. Riprap is used in areas where vegetation cannot be established to sufficiently reduce or prevent erosion. This includes channel slopes and bottoms, storm water structure inlets and outlets, slope drains, streambanks and shorelines.

Soddingis the continuous covering of exposed areas with rolls of grass to provide permanent stabilization. This procedure is especially useful in areas with a steep grade, where seeding is not conducive. As with mulching, sodding fosters vegetation growth, minimizes raindrop impact energy, increases surface roughness and reduces the velocity of runoff.

Temporary Gravel Construction Accessis a graveled area or pad on which vehicles can drop their mud and sediment. By providing such an area, erosion from surface runoff, transport onto public roads, and dust accumulation may be avoided. This BMP is designed to capture potentially exposed sediment sources so they may be further managed and controlled.

Temporary and Permanent Seedinginvolves planting areas with rapid-growing annual grasses, small grains, or legumes to provide stability to disturbed areas. Areas are temporarily seeded if the soils are not to be brought to final grade for more than approximately one month. Permanent seeding is established on areas which will be covered with vegetative growth for more than two years. This BMP establishes a relatively quick growing vegetative cover.

Topsoilingis the application of loose, rich, biologically active soil to areas with mildly graded slopes. Often, facilities will stockpile topsoil for future site use. To ensure that runoff contamination does not occur, sediment barriers and temporary seeding should be used.

6.1.2. Runoff Control and Conveyance Measures.

A ***Grass-Lined Channel***is a dry conduit vegetated with grass. Grass channels are used to conduct storm water runoff. In order for this system to function properly, the grass must be established and rooted before flows are introduced. Lining of the channels is required if design flows are to exceed 2 cubic feet per second (cfs). A grass channel increases shear stress within the channel, reduces flow velocities and promotes the deposition of sediments in storm water. The channel itself is also protected from erosion of the bed and sides.

Hardened Channelsare conduits or ditches lined with structural materials such as riprap or paving. These channels are designed for the conveyance, transfer, and safe disposal of excess storm water. These channels are often used in places with steeply graded slopes, prolonged flow, potential for traffic damage, erodible soils, or design velocity exceeding 5 cfs.

Paved Flumesare concrete-lined conduits that are set into the ground. Flumes are used to convey water down a relatively steep slope without causing erosion. This system should have an additional energy dissipation feature to reduce erosion or scouring at the outlet. Flumes also should be designed with an inlet bypass that routes extreme flows away from the flume.

Runoff Diversionsare temporary or permanent structures which channel, divert or capture runoff and transport it to areas where it can be used or released without erosion or flood damage. The types of structures used for this purpose include graded surfaces to redirect sheet flow, dikes or berms that force surface runoff around a protected area, and storm water conveyances which intercept, collect, and redirect runoff. Temporary diversion may be constructed by placing dikes of spoil materials or gravel on the down-gradient end of an excavated channel or swale. Permanent diversions, which are built to divide specific drainage areas when a larger runoff flows are expected, are sized to capture and carry a specific magnitude of design storm.

Temporary Slope Drainsare temporary structures constructed of flexible tubing or conduit which convey runoff from the top to the bottom of a cut or fill slope. In conjunction with diversions, these drains are used to convey concentrated runoff away from a cut or fill slope until more permanent measures, such as stabilization with vegetation, can be established.

6.1.3. Outlet Protection.

Level Spreadersare a type of outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope. The landscape of the receiving area must be uniformly sloped, the outlet lip leveled, and the land unsusceptible to erosion. To avoid the formation of a gully, hardened structures, stiff grass hedges, or erosion-resistant matting should be incorporated into the design. This type of outlet is often used for runoff diversions.

Outlet Stabilization Structuresare outlets that reduce outlet flow velocity and dissipate flow energy. These types of structures are used at the outlet of a channel or conduit where the discharge velocity exceeds that of the receiving area. The most common designs are riprap-lined aprons, riprap stilling basins, or plunge pools.

6.1.4. Sediment Traps and Barriers

Brush Barriersare temporary sediment barriers that are constructed to form a berm across or at the toe of a slope susceptible to interill and rill erosion. They may consist of limbs, weeds, vines, root mats, rock, or other cleared materials.

Check Damsare temporary, emergency, or permanent structures constructed across drainageways other than live streams where they are used to restrict flow velocity and reduce channel erosion. In their permanent application, these dams gradually accumulate sediment until they are completely filled. At that point, a level surface or delta is formed into a non-eroding gradient over which the water cascades to a dam through a spillway into a hardened apron. Other alternatives for protecting channel bottoms should be evaluated before selecting the check dam on a temporary basis. Dams may either be porous or nonporous. Porous dams will decrease the head of flow over spillways by releasing part of the flow through the actual structure.

Grade Stabilization Structuresare designed to reduce channel grade in natural or constructed channels to prevent erosion of a channel caused by increased slope or high flow velocities. This type of structure includes vertical-drop structures, concrete or riprap chutes, gabions, or pipe-drop structures. In areas where there are large water flows, concrete chutes or vertical-drop weirs constructed of reinforced concrete or sheet piling with concrete aprons are recommended. For areas with small flows, prefabricated metal-drop spillways or pipe overfall structures should be used.

Sediment Detention Basins can be either permanent pool or self dewatering (i.e., complete flow through) types. They are primarily designed to allow ponding of runoff or flows so eroded soils and sediments can settle out and be captured before they can enter streams or other water bodies. The design and use of these basins is perhaps the most important BMP applied to control erosion at mine sites. Section 6.2 provides a detailed discussion of important design and management considerations for Sediment Detention Basins.

Sediment Fence (Silt Fence)/Straw Bale Barriers are temporary measures used to control sediment loss by reducing the velocity of sheet flows. They consist of filter fabric buried at the bottom, stretched, and supported by posts, or straw bales staked into the ground. Overflow outlets and sufficient storage area need to be provided to control temporary ponding. Sediment Traps are small, temporary ponding basins formed by an embankment or excavation. These are less permanent structures than sediment detention basins. Outlets of diversion channels, slope drains, or other runoff conveyances that discharge sediment-laden water often use this system.Sediment traps should be designed to minimize the potential forshort circuiting, include features such as embankment protection and non-erosive emergencybypass areas, and provide for periodic maintenance.

Temporary Block and Gravel Inlet Protections are control barriers made of concrete block and gravel around a storm drain inlet. These structures filter sediment from storm water entering the inlet before soils have stabilized, while allowing the use of the inlet for storm water conveyance.

Temporary Excavated Drop Inlet Protections are temporary excavated areas around a storm drain inlet or curb designed to trap sediment. By trapping sediment before its entry into the inlet, the permanent inlet may be used before soils in the area are stabilized. This system requires frequent maintenance and can be used in combination with other temporary measures.

Temporary Fabric Drop Inlet Protections are fabric drapes placed around a drop inlet, on a temporary basis, during construction activities to protect storm drains. This practice can be used in combination with other temporary inlet protection devices.

Temporary Sod Drop Inlet Protection is a grass sod sediment filter area around a storm drain drop inlet. This is used when soils in the area are stabilized, and is suitable for the lawns of large buildings.

Vegetated Filter Strips (VFS) are natural or planted low-gradient vegetated areas consisting of relatively flat slopes which filter solids from overland sheet flow. Dense-culmed, herbaceous, erosion-resistant plant species are appropriate for vegetating these strips. The effectiveness VFSs is increased, if channelized flows are absent; however, the main factors influencing removal efficiency are vegetation type and condition, soil infiltration rate, and flow depth and travel time. Level spreaders are often used to promote even distribution of runoff across the VFS.

6.1.5. Stream Protection

Check dams, grade stabilization structures, and streambank stabilization techniques are also BMPs used for stream protection. An additional stream protection BMP is a ***Temporary Stream Crossing****.*These crossings may be in the form of a bridge, ford, or temporary structure installed across a stream or watercourse for short-term use by construction vehicles or heavy equipment. Wherever possible, bridges should be constructed in lieu of other types of stream crossings, because they cause the least damage to streambeds, banks, and surrounding floodplains, provide the least obstruction to flow, and have the lowest potential to increase erosion.

Culvert crossings are the most common and are the most destructive form of crossings. Culverts generally cause significant impacts to a stream bed and increase the potential for channel scour. Low-span bottomless arched conduits offer the simplicity of a culvert crossing and minimize impacts to the stream bed. These crossings can be placed over the top of stream channels without disturbing the streambed at the crossing. Fords are cuts in the banks with filter cloth held in place by stones. They are used in steep areas prone to flash flooding, but should be used only where crossings are infrequent and banks are low. Another technique which can be applied is to size a main culvert to handle normal bankfull flows. Additional culverts are then placed along side of the main culvert at a higher elevational base. The additional culverts route flood flows that exceed the capacity of the main culvert and would normally move out across a floodplain. The advantage to this design is that overly sized culverts can often cause channelization, increases in flow velocity and scouring of the channel down stream. A multiculvert design reduces these effects by sizing the main culvert to handle normal stream flows. All stream crossings should be located on a permanent basis to prevent overtopping and minimize erosion potential.

6.1.6. Sediment Detention Basins

Sediment detention basins are commonly used to prevent or control sediment deposition in streams and water bodies (Barfield et al., 1981). Detention basins are designed to capture runoff or conveyed storm water and reduce water velocity to allow sediments to settle out. Storm flows eventually pass through an outflow structure leaving the sediment (i.e., settleable solids) in the basin.

Detention basins must be designed to account for several storage volumes including:
1) a sediment storage volume (Vs);
2) a storage volume for detention storage (Vd);

3) and a final flood storage volume (Vf).

The design storage for Vs depends on the loading and volume of sediment that would be expected for a specific design period. The design period can be the life of the mine, or a shorter period in which accumulated sediments are periodically dredged or removed from the detention basin. Estimates for Vs are made using the methods or models to predict expected sediment yields entering the basin (see Section 4.2). In general, the USLE or the MUSLE are used to calculate sediment loading to a detention basin, either on an annual or a design storm basis. Vd is the storage volume that is required to detain and hold the volume of runoff from a specified design storm long enough to allow the sediment to settle out. A variety of methods are used to calculate storm runoff volume (Vf) (see Appendix A, *Hydrology)*. Vf is the final flood storage volume or free board which is added as contingency to prevent overtopping and dam failure during extreme events that exceed the design capacity.

Sediment detention basins are designed to maximize trap efficiency in order to minimize the release of suspended loads downstream at mine sites. Trap efficiency is defined as the ratio between the mass of sediment flowing into a basin and the mass of sediment flowing out of a basin. Barfield et al. (1981) outline several parameters that affect the performance and trap efficiency of a basin:

- Particle size distribution of sediments
- Detention storage time
- Reservoir shape, amount of dead storage, and turbulence
- Water chemistry
- The use of flocculants

Because sediment detention basins are usually flow-through structures, trap efficienciesare optimized by setting design criteria or goals that maximize the capture of all settleable solidsfor a given design storm (i.e., storm frequency). At mine sites, it is common practice to designsediment detention basins based on the 10-year, 24-hour precipitation event. This designstandard is based on the criteria for exemption for discharge of excess storm water at mine sites.

The particle size distribution sediments flowing into a detention basin is the single most important factor affecting trap efficiency (Barfield et al., 1981), because particle size is directly related to settling velocity. Assuming steady-state flow through a reservoir, a decrease in particle or aggregate size requires an increased flow length to allow a particle to settle out. For this reason, accurate characterization of particle size distributions of potentially incoming sediments is critical to pond design and management.

The detention storage time is the volume-weighted average time that a volume of flow will be detained in a reservoir. The detention time of a settling basin is a function of basin shape, basin length and the design of the outlet structure. The design of the outflow structure determines the characteristics of the outflow hydrograph and its relationships to the inflow hydrograph.

Basin shape strongly influences how effectively the storage volume of the basin is used for sedimentation. The basin shape determines flow path length, flow velocity, areas of turbulence within the basin, and if dead storage areas occur. Small localized zones of turbulence within the basin can inhibit particle settling because of locally increased flow velocities. Dead storage areas are zones within the basin that are bypassed and, therefore, ineffective in the settling process. EPA (1976) suggests that dead storage volume can be minimized by maintaining a 2:1 ratio between reservoir length (i.e., the length of the flow path) and reservoir width.

Water chemistry also affects particle settling and trap efficiency. In general, the ionic strength of the water is a primary factor affecting particle flocculation or dispersion. Flocculation of particles to larger, heavier aggregates generally increases with increased ionic strength. The types of cations present, however, also affect this process. Because they are divalent, calcium and magnesium cations tend to be very effective in increasing flocculation. Effects of ionic strength on flocculation and dispersion can be specifically related, therefore, to the relative concentrations of these cations in solution. The Exchangeable Sodium Percentage (ESP) and the Sodium Absorption Ration (SAR) are useful parameters that should be examined when evaluating the effects of water chemistry (Barfield et al., 1981).

Flocculant, which are compounds that enhance the aggregation of particles, often are used to aid the performance of a detention basin and, in some cases, to ensure that water quality standards are met at the basin outlet. Flocculants create larger particles that have greater settling velocities. They can be particularly useful when a large proportion of entrained sediment are clay, fine silt, or colloidal materials. Colloidal particles remain in suspension and will not settle out even under quiescent conditions. Barfield et al. (1981) provides a detailed discussion on water chemistry, flocculation and the design of programs in enhance settling using flocculants in sediment detention basins.

CAD and modeling software usually is employed to design sediment detention basins. In particular, SEDCAD+, PONDPACK, and SEDIMOT II, described in Section 4.3.2, are specifically used to apply both hydrologic and erosion measurements to the design of sediment detention basins. Using these types of software, a hydrologist can iteratively design detention basins to optimize basin size and shape, detention storage time, and the type of outflow structure required to meet design criteria. These models provide analyses of both inflow and outflow hydrographs and inflow and outflow sedigraphs. Analyses are performed to provide estimates of trap efficiency, mass of settleable solids captured, and mass of suspended solids not retained by the basin. Basins designed using software packages depend on accurate input data for hydrologic and soil variables. In particular, accurate information regarding soil types and particle size distributions (texture) are necessary for accurate design.

6.5 INNOVATIVE CONTROL PRACTICES

Most erosion and sediment control BMPs have been standard practice for many years. As discussed in Section 6.1, standard BMPs include surface stabilization measures, diversions and channels, and sediment traps and barriers. Some innovative BMPs, however, include variations of these practices that offer particularly effective controls. These practices include:

- The design and construction of artificial wetlands to provide natural filtration and enable sediment deposition. Artificial or constructed wetlands can effectively remove suspended solids, particulates and metals attached to sediments through the physical processes of velocity reduction, filtration by vegetation, and chemical precipitation as water flows through the wetlands.
- The use of geotextiles for soil stabilization and erosion control blankets and mattings. Geotextiles can be made of natural or synthetic materials and are used to temporarily or permanently stabilize soil. Synthetic geotextiles are fabricated from nonbiodegradable materials and are generally classified as either Turf Reinforcement Mats (TRMs) or Erosion Control and Revegetation Mats (ECRMs). TRMs are three dimensional polymer nettings or monofilaments formed into a mat to protect seeds and increase germination. ECRMs are

composed of continuous monofilaments bound by heat fusion or stitched between nettings. They serve as a permanent mulch.

- Biotechnical stabilization techniques that use layers of live brush to help stabilize slopes. Biotechnical stabilization can control or prevent surface erosion and mass slope failures. This technique involves the use of cut branches and stems of species such as willow, alder and poplar. The live brush is embedded into the ground in a criss-cross pattern so that roots and shoots will eventually develop. Biotechnical stabilization is most effective when shrubs are cut and utilized during dormant periods.

7 SUMMARY

Mining activities have the potential to expose large areas of soil and rock to the processes of erosion. Mine pits, roads, tailings dams, waste rock and ore piles, and other facilities are potential sources of sediment that can be transported and deposited in streams and other water bodies. If properly planned and managed, however, adverse impacts to water quality and aquatic resources can be minimized or prevented. To prevent potential impacts, water and sediment management needs to be considered from the beginning of any mining plan.

The development of an effective erosion control plan must start with accurate baseline characterization of erosion and sediment potentials on a watershed basis. Accurate knowledge of existing conditions is necessary to design and implement effective erosion control programs and to allow accurate monitoring for impacts. Baseline characterization depends on sampling programs that adequately determine existing soil types and their particle size distributions, existing vegetation types and cover values, slopes and slope lengths, as well as the relationships between existing drainages and stream channels. Programs to characterize baseline water quality must take into account variations in stream flow. This includes variations that occur on a storm basis, as well as on a seasonal or annual basis. Developing monitoring programs that accurately detect or evaluate impacts and control effectiveness depends on having accurate knowledge of natural erosion and degradation rates and patterns.

The choice of methods to predict gross erosion and sediment yield from natural or disturbed areas may be dependent on the type of input data required. It is very important that the mining hydrologist understands all assumptions inherent in a model or method when conducting analyses to predict sediment yields or design erosion controls. Accurate analyses by available software programs and models requires accurate site-specific sampling for input data. Vegetation parameters, soil types, and soil particle size distributions are, perhaps, the most important parameters that are input to predictive models and CAD programs.

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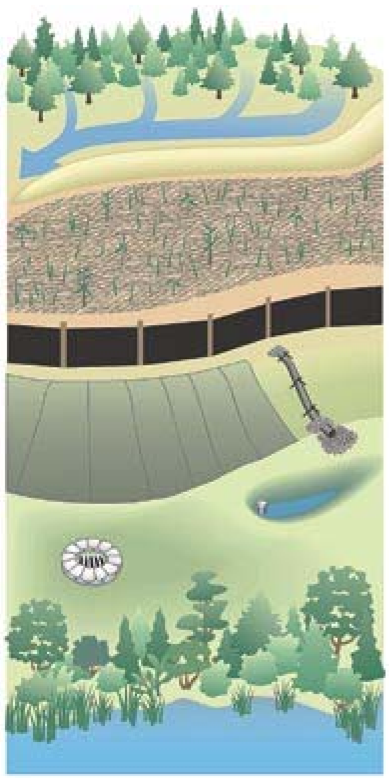
ATTACHMENT D-2

RULES OF THUMB FOR EROSION AND SEDIMENT CONTROL
(Excerpted from Kentucky Erosion Prevention and Sediment Control Field Guide)
TETRA TECH funded by
Kentucky Division of Water (KDOW), Nonpoint Source Section
and the Kentucky Division of Conservation (KDOC) through a grant from USEPA
http://www.epa.gov/region8/water/stormwater/pdf/Kentucky%20Erosion%20prevention%20field%20guide.pdf

The following attachment presents illustrations and photographs of Best Management Practices for Erosion and Sediment Control. This information was excerpted from the US EPA funded Kentucky Erosion Prevention and Sediment Control Field Guide. This Guide is presented in entirety on the CD-ROM accompanying this guideline. This attachment intends to give a practical approach towards the management of runoff and control of erosion and sediment from a mining site.

BASIC RULES



Preserve existing Vegetation

Divert upland runoff around exposed soil

Seed/mulch/ cover bare soil immediately

Use sediment barriers to trap soil in runoff

Protect slopes and channels from gullying

Install sediment traps and settling basins
Preserve vegetation
Near all waterways

NEED FOR EROSION AND SEDIMENT CONTROL MEASURES

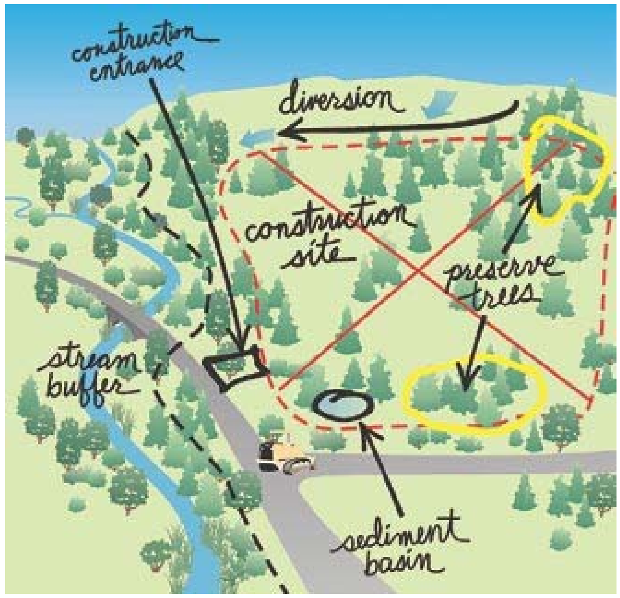
	Soil Type		
Slope Angle	**Silty**	**Clays**	**Sandy**
Very Steep (2:1 or more)	*Very high*	*High*	*High*
Steep (2:1–4:1)	*Very High*	*High*	*Moderate*
Moderate (5:1–10:1)	*High*	*Moderate*	*Moderate*
Slight (10:1–20:1	*Moderate*	*Moderate*	*Low*

PRIORIZATION OF EROSION AND SEDIMENT CONTROL MEASURES

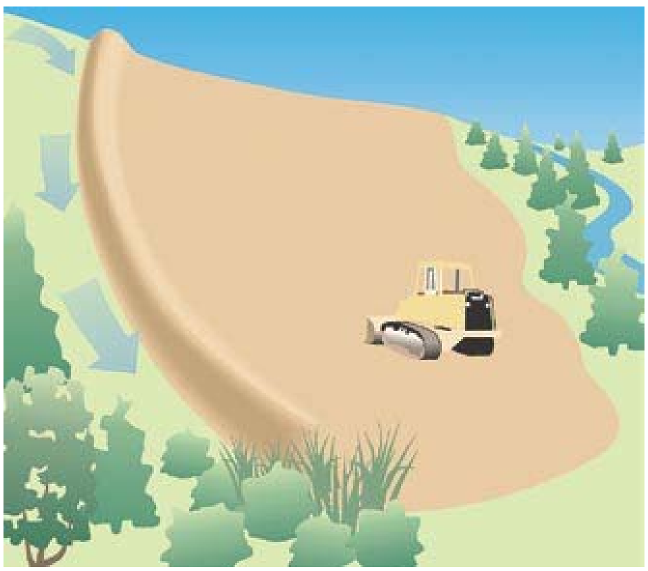
PRACTICE	COST	EFFECTIVENESS
Limiting disturbed area through phasing	$	*****
Protecting disturbed areas with mulch and revegetation	$$	****
Installing diversions around disturbed areas	$$$	***
Sediment removal through detention of all site drainage	$$$$	**
Other structural controls to contain sediment laden drainage	$$$$$	*

PLAN AHEAD

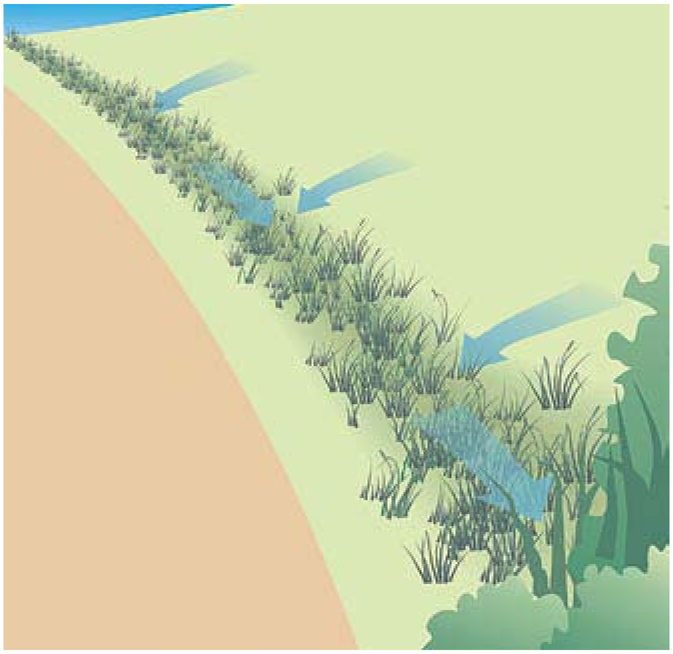
Identify drainage areas and plan for drainage ditches and channels, diversions, grassed channels, sediment traps/basins, down slope sediment barriers, and rock construction and install before beginning excavation.



DIVERT RUNOFF AROUND EXCAVATION AND DISTURBANCE



Berms and ditches diverting clean upland runoff around constructionsites reduce erosion and sedimentation problems. Seed berms andditches after construction.

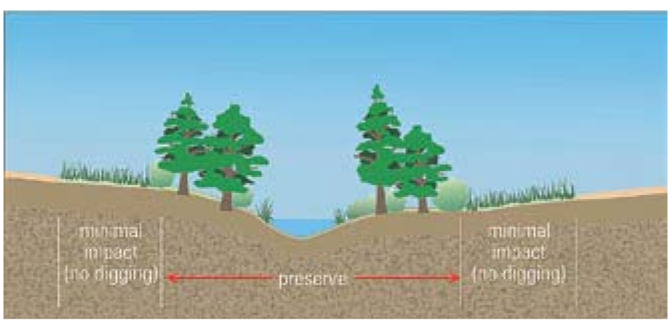


Diversion ditches should be lined with grass at a minimum, and blanketsif slopes exceed 10:1

Vegetated buffers above or below your work site are always a plus.

They trap sediment before it can wash into waterways, and preventbank erosion.

VEGETATIVE BUFFERS



Vegetated waterways help move upland water through or past your site while keeping it clear of mud. Do not disturb existing vegetation along banks, and leave a buffer of tall grass and shrubs between stream bank trees and disturbed areas.

Good construction, seeding, and stabilization of diversion berm. Notethat diversion ditch is lined with grass on flatter part of slope, and withrock on steeper part.

SOIL COVER VS EROSION PROTECTION

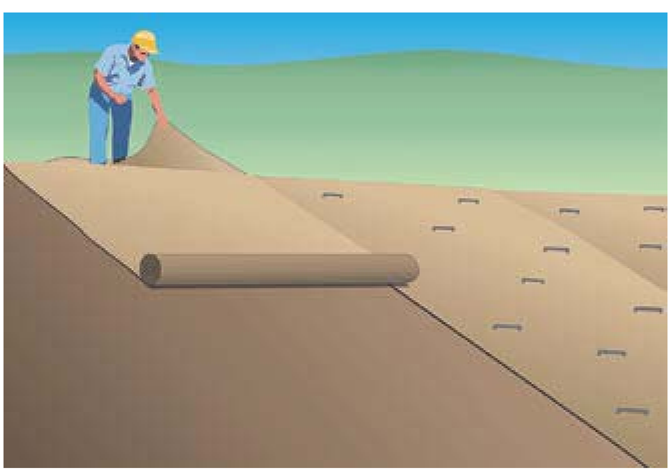
Soil covering	Erosion reduction
Mulch (hay or straw)	
1.2 ton per 0.4 hectare	75 percent
1 ton per 0.4 hectare	87 percent
2 tons per 0.4 hectare	98 percent
Grass (seed or sod)	
40 percent cover	90 percent
60 percent cover	96 percent
90 percent cover	99 percent
Bushes and shrubs	
25 percent cover	60 percent
75 percent cover	72 percent
Trees	
25 percent cover	58 percent
75 percent cover	64 percent
Erosion control blankets	95–99 percent

Prepare bare soil for planting by disking across slopes, scarifying, or tilling if soil has been sealed or crusted over by rain. Seedbed must be dry with loose soil to a depth of 3 to 6 inches.

For slopes steeper than 4:1, walk bulldozer or other tracked vehicle up and down slopes beforeseeding to create tread-track depressions for catching and holding seed. Mulch slopes after seeding if possible. Cover seed with erosion control blankets or turf mats if slopes are 2:1 or greater. Apply more seed to ditches and berms.

Erosion and sediment loss is virtually eliminated on seeded areas (left side). Rills and small gullies form quickly on unseeded slopes (right).

BLANKET INSTALLATION (GEOFABRIC)

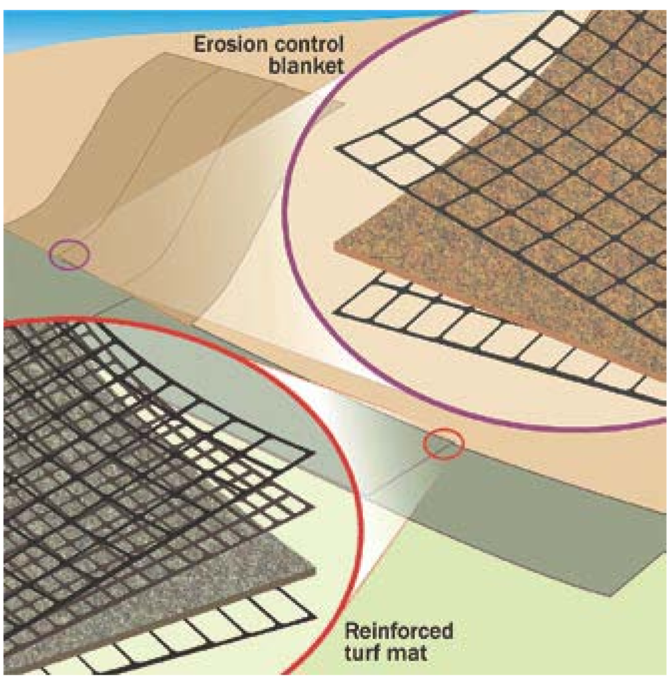


Install blankets and mats vertically on long slopes. Unroll from top ofhill, staple as you unroll it. Do not stretch blankets.

Erosion control blankets are thinner and usually degrade quicker than turf reinforcement mats. Check manufacturer's product informationfor degradation rate (life span), slope limitations, and installation.

Remember to apply seed, fertilizer, and lime before covering withblankets or mats!

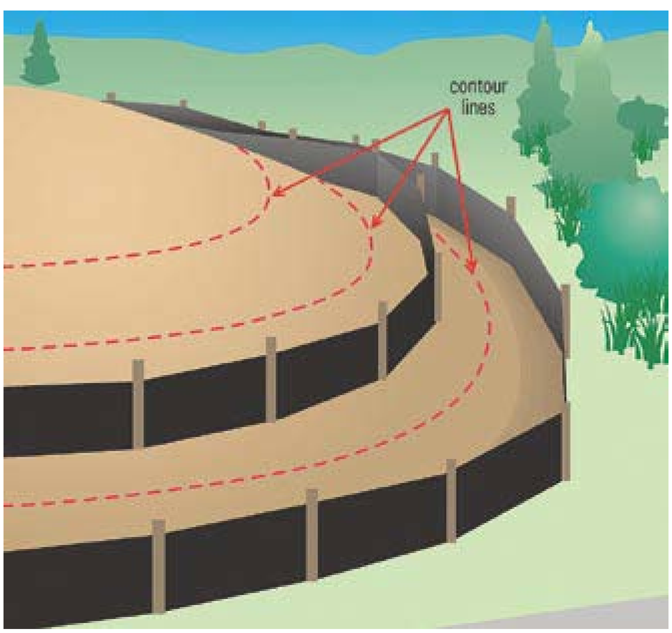
Blankets installed along stream banks or other short slopes can be laid horizontally. Install blankets verticallyon longer slopes. Ensure 15 cm minimum overlap.



BLANKET INSTALLATION

SITE CONDITIONS	BLANKET INSTALLATION NOTES
Ditches and channels (from high flow line to ditch bottom)	• Grade, disk, and prepare seedbed. • Seed, lime, and fertilize the area first • Install horizontally (across slope). • Start at ditch bottom. • Staple down blanket center line first. • Staple & bury top in 8" deep trench. • Top staples should be 12" apart. • Uphill layers overlap bottom layers. • Side overlap should be 6"–8". • Side & middle staples = 24" apart. • Staple below the flow level every 12". • Staple thru both blankets at overlaps
Long slopes, including areas above ditch flow levels	.• Grade, disk, and prepare seedbed. • Seed, lime, and fertilize first. • Install vertically (up & down hill). • Unroll from top of hill if possible. • Staple down center line of blanket first. • Staple & bury top in 8" deep trench. • Top staples should be 12" apart. • Side & middle staples = 24" apart. • Uphill layers overlap downhill layers. • Overlaps should be 6"–8". • Staple thru both blankets at overlap.

SEDIMENT BARRIERS (Silt fences and others)



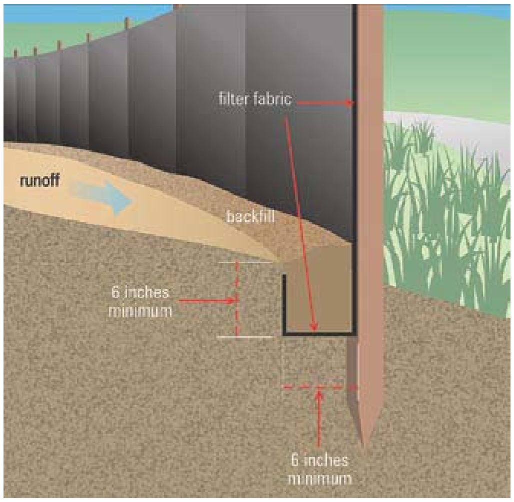
Silt fences should be installed on the contour below bare soil areas.

Use multiple fences on long slopes 20 to 26 meterst apart. Remove accumulatedsediment before it reaches halfway up the fence.
Each 33-meter section of silt fence can filter runoff from about 0.6 hectare (about 35 meters uphill). To install a silt fence correctly, follow these steps:

- Note the location & extent of the bare soil area.
- Mark silt fence location just below bare soil area.
- Make sure fence will catch all flows from area.
- Dig trench 15 centimeters deep across

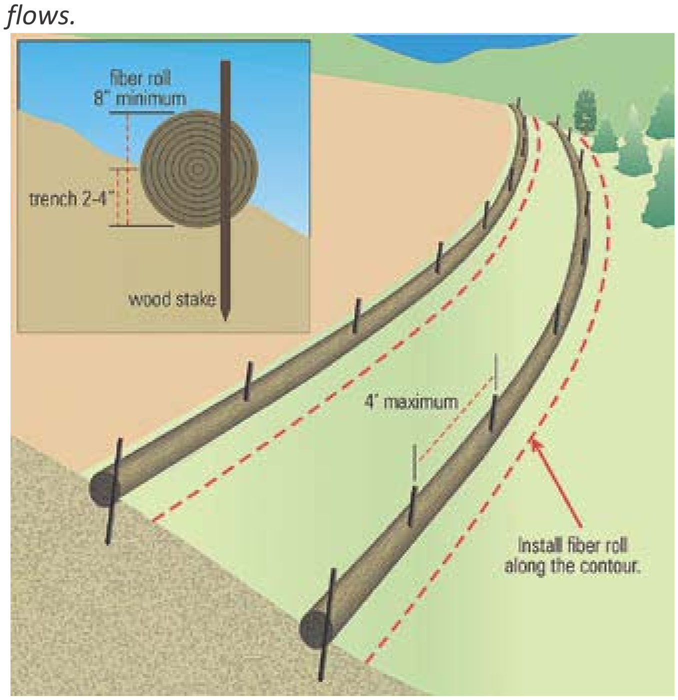
slope.

- Unroll silt fence along trench.
- Join fencing by rolling the end stakes together.
- Make sure stakes are on downhill side of fence.
- Drive stakes in against downhill side of trench.
- Drive stakes until 20 to 25 centimeters of fabric is in trench.
- Push fabric into trench; spread along bottom.
- Fill trench with soil and tamp down.



Stakes go on the downhill side. Dig trench first, installfence in downhill side of trench, tuck fabric into trench, then backfill on the uphill side (the side toward the bare soil area).

Use J-hooks to trap and pond muddy runoff flowing along uphill side of silt fence. Turn ends of silt fence toward the uphill side to prevent bypassing. Use multiple J-hooks every 17 to 50 meters for heavier flows.



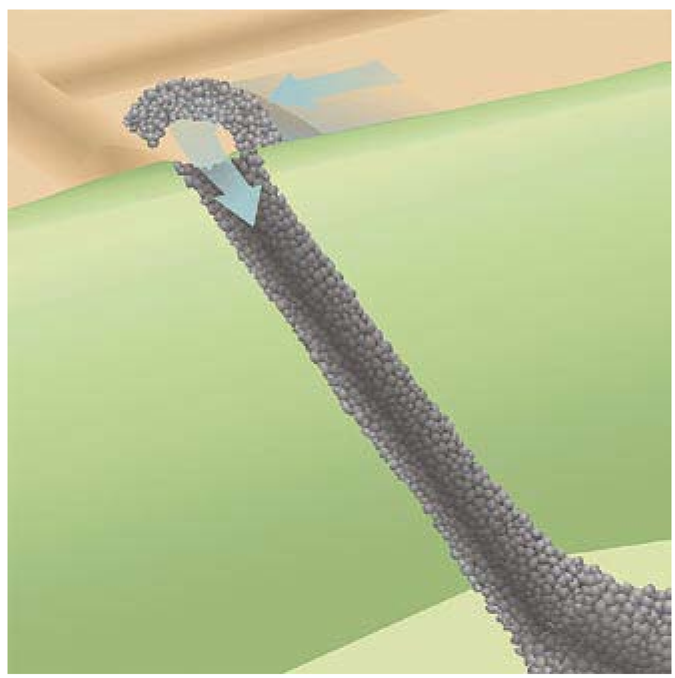
Fiber rolls can be used to break up runoff flows on long slopes. Installon the contour and trench in slightly. Press rolls firmly into trench andstake down securely. Consult manufacturer's instructions for expectedlifespan of product, slope limits, etc. As always, seed and mulch longslopes as soon as possible.

Very good installation of multiple silt fences on long slope. Turn ends of fencing uphill to prevent bypass. Leave silt fences up until grass is well established on all areas of the slope. Re-seed bare areas as soon as possible. Remove or spread accumulated sediment and remove silt fence after all grass is up.

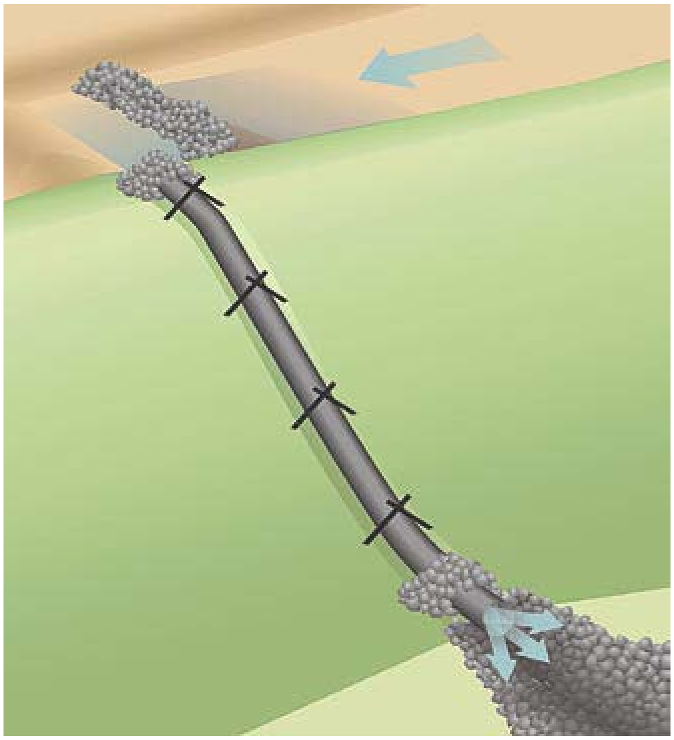
SLOPE PROTECTION TO PREVENT GULLIES

If soil is:	Erosion will be:
Compacted and smooth	30 percent *more*
Tracks across slopes	20 percent *more*
Tracks up & down slopes	10 percent *less*
Rough and irregular	10 percent *less*
Rough & loose to 12" deep	20 percent *less*

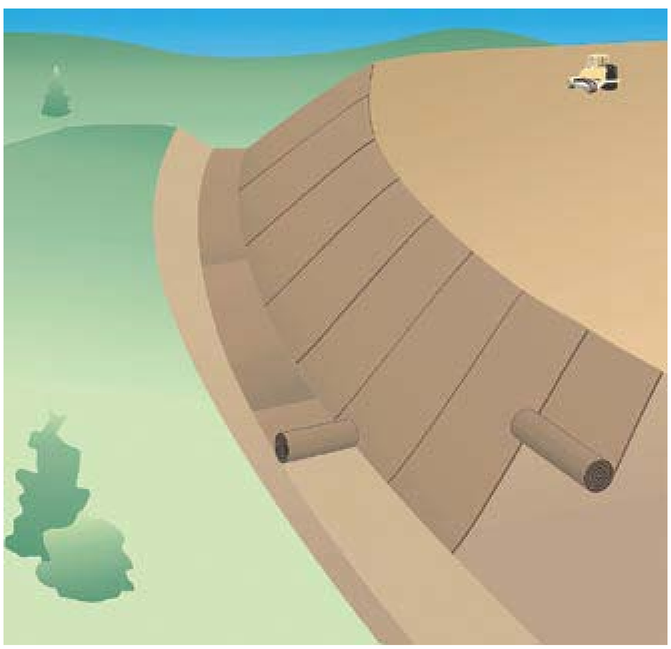
Tread-track slopes up and down hill to improve stability.



Temporary downdrain using plastic pipe. Stake down securely, andinstall where heavy flows need to be transported down highly erodibleslopes. Note silt check dam in front of inlet.



Temporary or permanent downdrain using geotextile underliner andriprap. All slope drains must have flow dissipaters at the outlet toabsorb high energy discharges, and silt checks at the inlet until grassis established.



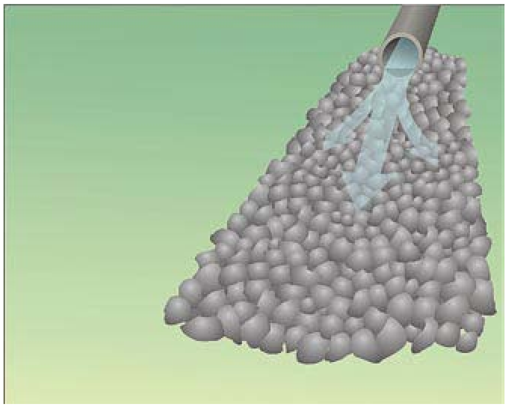
Steep, long slopes need blankets or mats. Install blankets and mats up and down long slopes. For channels below slopes, install horizontally. Don't forget to apply seed, lime, and fertilizer (if used) before installing blanket.

Other methods that could be considered are

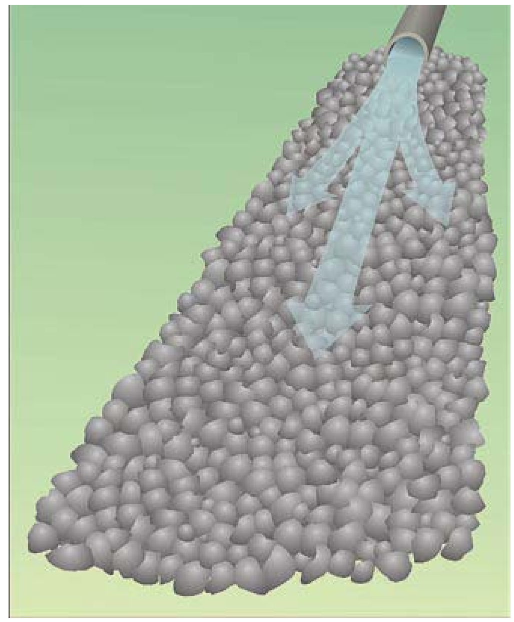
breaking up steep slopes with terraces, ditches along contours, straw bales and other methods.

PROTECTING DITCHS AND CULVERTS INLETS/OUTLETS

Very good application of mixed rock for culvert inlet ponding dam. Mixingrock promotes better ponding, drainage, and settling of sediment.



Low-flow energy dissipaters (above) are shorter than those for high-flow outlets (below).

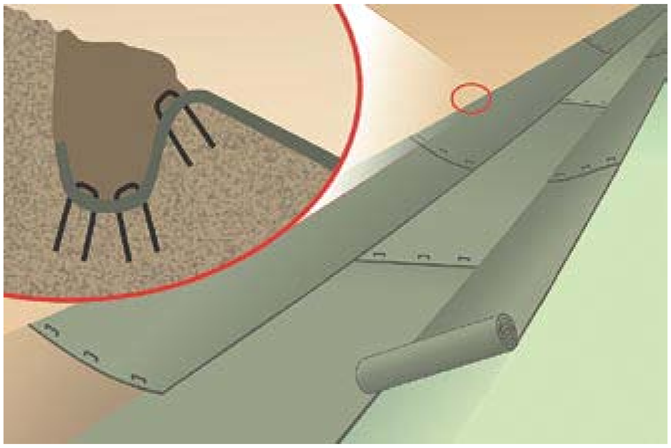


Excellent placement and construction of rock apron to dissipate flows from culvert outlet. Area needs seeding and mulching.

STABILIZING DRAINAGE DITCHES

Stabilization approaches for drainage ditches

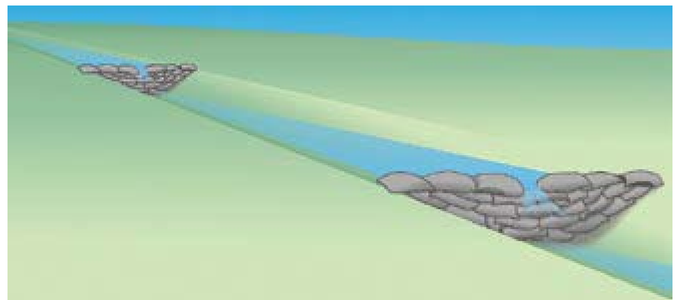
	Soil Type in Ditch		
Ditch Slope	Sandy	Silty	Clays
Steep >10%	Concreteor riprap	Concreteor riprap	Riprap
Moderate 10%	Riprap withfilter fabric	Riprap orturf mats &seeding	Riprap orturf mats& seeding
Slight 5%	Riprap orturf mats &seeding	Seeding &turf mats	Seeding &turf mats
Mostly Flat <3%	Seeding &blankets	Seeding &mulching	Seeding &mulching



Lay in ditch blankets similar to roof shingles; start at the lowest part of the ditch, then work your way up. Uphill pieces lap over downhill sections. Staple through both layers around edges. Trench, tuck, and tamp down ends at the top of the slope. Do not stretch blankets or mats.

Check Dams

Silt check dams of rock, stone-filled bags, or commercial products must be installed before uphill excavation or fill activities begin. See table below for correct silt check spacing for various channel slopes. Tied end of bag goes on downstream side.



Spacing of Check Dams in Ditches

Ditch Slope	Check Dam Spacing (meters)	Additional Information
30%	*3.2*	*Calculated for 1 meter high check dam*
20%	*5*	
15%	*7*	
10%	*12*	*Center of the dam should be 150 centimeters lower than the sides*
5%	*17*	
3%	*33*	
2%	*50*	*Use 15 to 25 cm rock, stone bags, or commercial products*
1%	*100*	
0.5%	*200*	

Good installation of temporary rock silt checks. Remember to tie sides of silt check to upper banks. Middle section should be lower. Clean out sediment as it accumulates. Remove silt checks after site and channel are stabilized with vegetation.

Good placement and spacing of fiber-roll silt checks. Coconut fiber rolls and other commercial products can be used where ditch slopes do not exceed three percent.

DITCH LINING

Ditch lined with rock.

Rock Sizing for ditch liners

Flow Velocity	Average rock diameter
2 m/sec	12.5 cm
2.5 m/sec	25.0 cm
3.3 m/sec	35.0 cm
4 m/sec	50.0 cm

SEDIMENT TRAPS AND BASINS

In general, sediment traps are designed to treat runoff from about 1 to 5 acres. Sediment basins are larger, and serve areas of about 5 to 10 acres. Basins draining areas larger than 10 acres require an engineered design, and often function as permanent storm water treatment ponds after construction is complete.

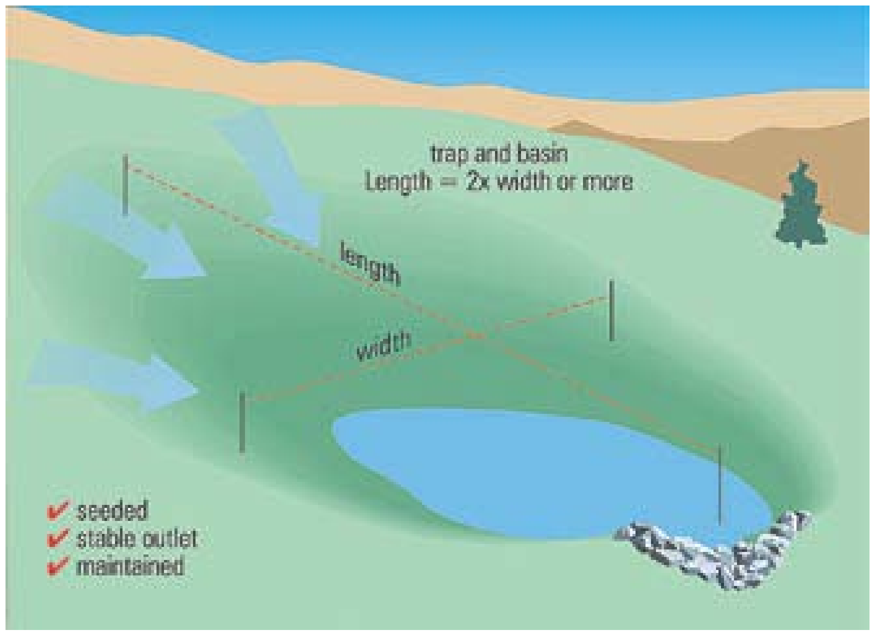
Sediment traps

Any depression, swale, or low-lying place that receives muddy flows from exposed soil areas can serve as a sediment trap. Installing several small traps at strategic locations is often better than building one large basin. The simplest approach is to dig a hole or build a dike (berm) of earth or stone where concentrated flows are present. This will help to detain runoff so sediment can settle out. The outlet can be a rocklined depression in the containment berm.

Sediment basins

Sediment basins are somewhat larger than traps, but the construction approach is the same . Sediment basins usually have more spillway protection due to their larger flows. Most have risers and outlet pipes rather than rock spillways to handle the larger flows. Sediment basins are often designed to serve later as storm water treatment ponds. If this is the case, agreements are required for long-term sediment removal and general maintenance. Construction of a permanent, stable outlet is key to long-term performance.

Sizing and design considerations



A minimum storage volume of 130 cubic meters per 0.4 hectare of exposed soil drained is required for basins and traps. Traps and basins are designed so that flow paths through the trap or basin are as long as possible, to promote greater settling of soil particles. Sediment basin length must be twice the width or more if possible—the longer the flow path through the basin, the better.

Side slopes for the excavation or earthen containment berms are 2:1 or flatter. Berms are made of well-compacted clayey soil, with a height of 1.5 meters or less. Well mixed rock can also be used as a containment berm for traps. Place soil fill for the berm or dam in 15 cm layers and compact. The entire trap or basin, including the ponding area, berms, outlet, and discharge area, must be seeded and mulched immediately after construction. An overflow outlet can be made by making a notch in the containment berm and lining it with rock. Rock in the notch must be large enough to handle over-flows, and the downhill outlet should be stabilized with rock or other flow dissipaters similar to a culvert outlet. Overflow should be at an elevation so dam will not overtop. Allow at least 0.33 meter of freeboard. Outlets must be designed to promote sheet flow of discharges onto vegetated areas if possible. If the discharge will enter a ditch or channel, make sure it is stabilized with vegetation or lined.

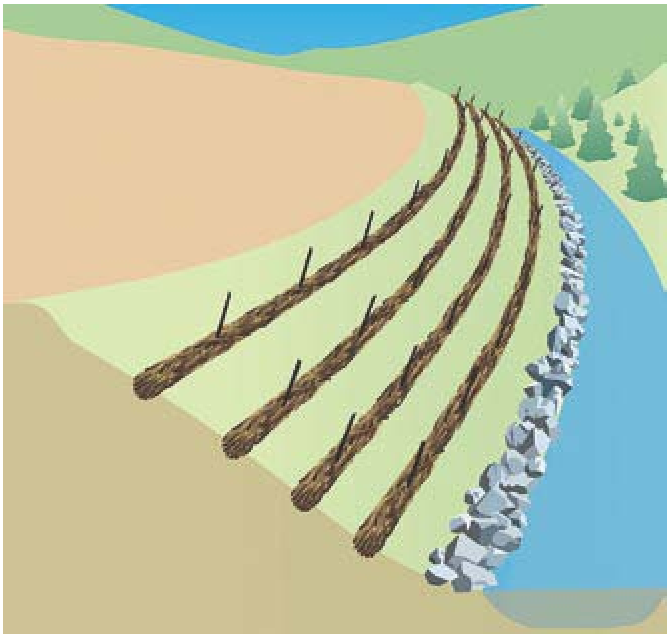
PROTECTING STREAMS AND STREAM BANKS

Recommended Setbacks of Activities from Streams

	Soil Type Along Banks		
Bank Slope	**Sandy**	**Silty**	**Clays**
Very Steep (2:1 or more)	33 m	27 m	20 m
Steep (4:1 or more)	27 m	20 m	13 m
Moderate (6:1 or more)	20 m	13 m	10 m
Mostly flat (< 10:1)	13 m	10 m	6.5 m

Vegetated buffers

Preserve existing vegetation near waterways wherever possible. This vegetation is the last chance barrier to capture sediment runoff before it enters the lake, river, stream, or wetland. Where vegetation has been removed or where it is absent, plant native species of trees, shrubs, and grasses.



Live hardwood stakes driven through live wattles or rolls, trenched into slope, provide excellent stream bank protection. Protect toe of slope with rock or additional rolls or rocks.

STREAM CROSSINGS

Keep equipment away from and out of streams. If a temporary crossing is needed, put it where the least stream or bank damage will occur. Look for:

- Hard stream bottom areas
- Low or gently sloping banks
- Heavy, stable vegetation on both sides

Use one or more culverts, as needed, sized to carry the two-year 24-hour rain storm. Cover culverts with at least 27 cm of soil and at least 15 cm inches of mixed rock. A 8.5 meter long, 15 cm thick pad of rock should extend down the haul road on each side of the crossing.

Good use of silt fence, straw, rock, and other practices for temporary stream crossing. Any work in stream channels—such as installation of culverts

APPENDIX E. GARD GUIDE(ACID ROCK DRAINAGE)

1 INTRODUCTION

The Global Acid Rock Drainage (GARD) Guide addresses the prediction, prevention, and management of drainage produced from sulfide mineral oxidation, often termed “acid rock drainage” (ARD), “acid mine drainage” or “acid and metalliferous drainage” (AMD), “mining influenced water” (MIW), “saline drainage” (SD), and “neutral mine drainage” (NMD).

This Executive Summary follows the general structure of the full GARD Guide, a state-of-practice summary of the best practices and technologies, developed under the auspices of the International Network for Acid Prevention (INAP) to assist ARD stakeholders, such as mine operators, regulators, communities, and consultants, with addressing issues related to sulfide mineral oxidation. Readers are encouraged to make use of the GARD Guide and its references for further detail on the subjects covered in this Executive Summary. The GARD Guide was prepared with the input and assistance of many individuals and organizations, and their contributions are gratefully acknowledged.

Acid rock drainage is formed by the natural oxidation of sulfide minerals when exposed to air and water. Activities that involve the excavation of rock with sulfide minerals, such as metal and coal mining, accelerate the process. The drainage produced from the oxidation process may be neutral to acidic, with or without dissolved heavy metals, but always contains sulfate. ARD results from a series of reactions and stages that typically proceed from near neutral to more acidic pH conditions. When sufficient base minerals are present to neutralize the ARD, neutral mine drainage or saline drainage may result from the oxidation process. NMD is characterized by elevated metals in solution at circumneutral pH, while SD contains high levels of sulfate at neutral pH without significant dissolved metal concentrations. Figure 1 presents the various types of drainage in a schematic manner.

Stopping ARD formation, once initiated, may be challenging because it is a process that, if unimpeded, will continue (and may accelerate) until one or more of the reactants (sulfide minerals, oxygen, water) is exhausted or excluded from reaction. The ARD formation process can continue to produce impacted drainage for decades or centuries after mining has ceased, such as illustrated by this portal dating from the Roman era in Spain (Figure 2)

The cost of ARD remediation at orphaned mines in North America alone has been estimated in the tens of billions of U.S. dollars. Individual mines can face post-closure liabilities of tens to hundreds of million dollars for ARD remediation and treatment if the sulfide oxidation process is not properly managed during the mine’s life.

Figure 1: Types of Drainage Produced by Sulphide Oxidation

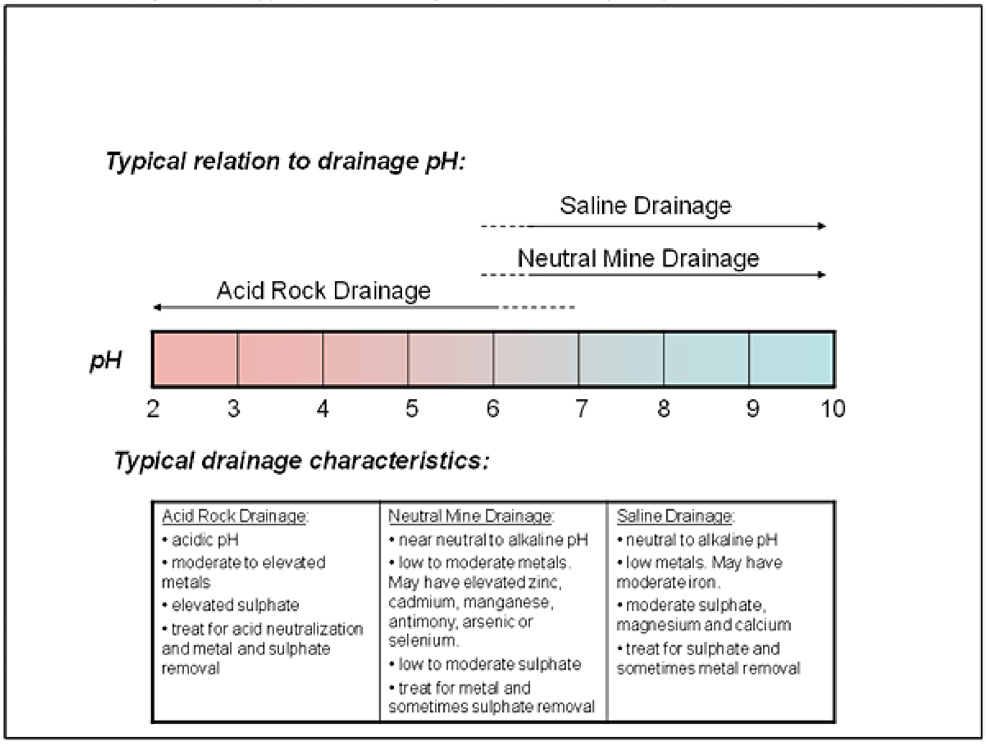
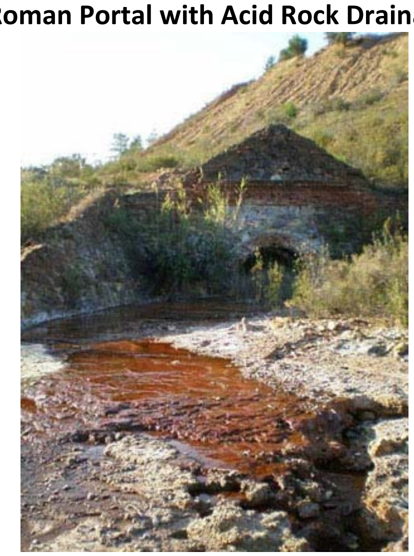


Figure 2: Roman Portal with Acid Rock Drainage – Spain



Proper mine characterization, drainage-quality prediction, and mine-waste management can prevent ARD formation in most cases, and minimize ARD formation in all cases. Prevention of ARD must commence at exploration and continue throughout the mine-life cycle. Ongoing ARD planning and management is critical to the successful prevention of ARD.

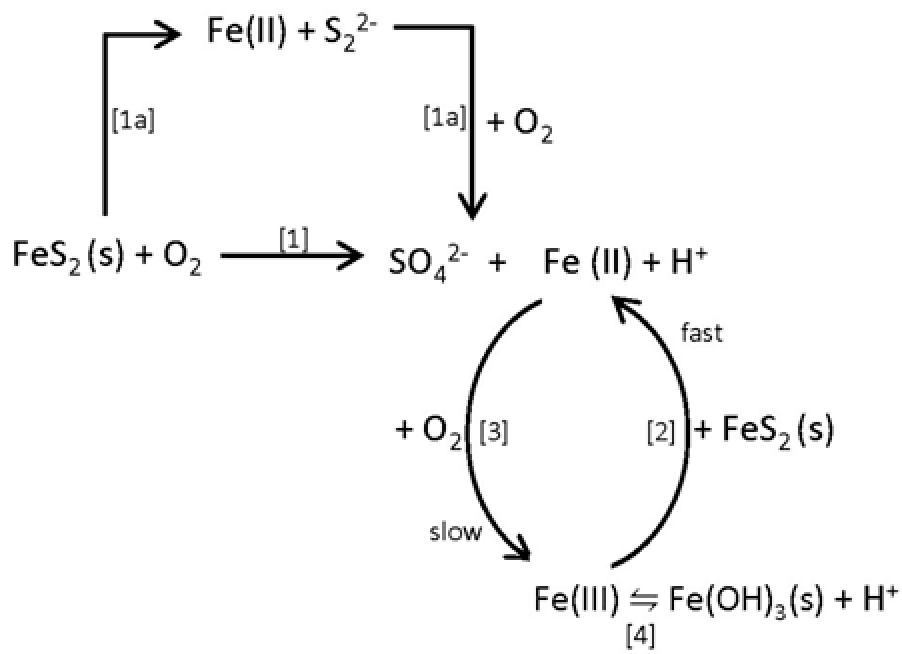
Many mines will not produce ARD because of the inherent geochemical characteristics of their mining wastes or very arid climatic conditions. In addition, mines that have implemented well founded prediction efforts and, where required, prevention measures and monitoring programs, should also be able to avoid significant ARD issues.

A comprehensive approach to ARD management reduces the environmental risks and subsequent costs for the mining industry and governments, reduces adverse environmental impacts, and promotes public support for mining. The extent and particular elements of the ARD management approach that should be implemented at a particular operation will vary based on many site-specific factors, not limited to the project's potential to generate ARD.

2 FORMATION OF ACID ROCK DRAINAGE

The process of sulfide oxidation and formation of ARD, NMD, and SD is very complex and involves a multitude of chemical and biological processes that can vary significantly depending on environmental, geological and climate conditions (Nordstrom and Alpers, 1999). Sulfide minerals in ore deposits are formed under reducing conditions in the absence of oxygen. When exposed to atmospheric oxygen or oxygenated waters due to mining, mineral processing, excavation, or other earthmoving processes, sulfide minerals can become unstable and oxidize. Figure 3 presents a simplified model describing the oxidation of pyrite, which is the sulfide mineral responsible for the large majority of ARD (Stumm and Morgan, 1981). The reactions shown are schematic and may not represent the exact mechanisms, but the illustration is a useful visual aid for understanding sulfide oxidation.

Figure 3: Model for the Oxidation of Pyrite (Stumm and Morgan, 1981).



The chemical reaction representing pyrite oxidation (reaction [1]) requires three basic ingredients: pyrite, oxygen, and water. This reaction can occur both abiotically or biotically (i.e., mediated through microorganisms). In the latter case, bacteria such as *Acidithiobacillus ferrooxidans*, which derive their metabolic energy from oxidizing ferrous to ferric iron, can accelerate the oxidation reaction rate by many orders of magnitude relative to abiotic rates (Nordstrom, 2003). In addition to direct oxidation, pyrite can also be dissolved and then oxidized (reaction [1a]).

Under the majority of circumstances, atmospheric oxygen acts as the oxidant. However, aqueous ferric iron can oxidize pyrite as well according to reaction [2]. This reaction is considerably faster (2 to 3 orders of magnitude) than the reaction with oxygen, and generates substantially more acidity per mole of pyrite oxidized. However, this reaction is limited to conditions in which significant amounts of dissolved ferric iron occur (i.e., acidic conditions: pH 4.5 and lower). Oxidation of ferrous iron by oxygen (reaction [3]) is required to generate and replenish ferric iron, and acidic conditions are required for the latter to remain in solution and participate in the ARD production process. As indicated by this reaction, oxygen is needed to generate ferric iron from ferrous iron. Also, the bacteria that may catalyze this reaction (primarily members of the *Acidithiobacillus genus*) demand oxygen for aerobic cellular respiration. Therefore, some nominal amount of oxygen is needed for this process to be effective even when catalyzed by bacteria, although the oxygen requirement is considerably less than for abiotic oxidation.

A process of environmental importance related to ARD generation pertains to the fate of ferrous iron resulting from reaction [1]. Ferrous iron can be removed from solution under slightly acidic to alkaline conditions through oxidation and subsequent hydrolysis and the formation of a relatively insoluble iron (hydr)oxide (reaction [4]). When reactions [1] and [4] are combined, as is generally the case when conditions are not acidic (i.e., pH > 4.5), oxidation of pyrite produces twice the amount of acidity relative to reaction [1] as follows:

$FeS_2 + 15/4O_2 + 7/2H_2O = Fe(OH)_3 + 2SO_4^{2-} + 4H^+$, which is the overall reaction most commonly used to describe pyrite oxidation.

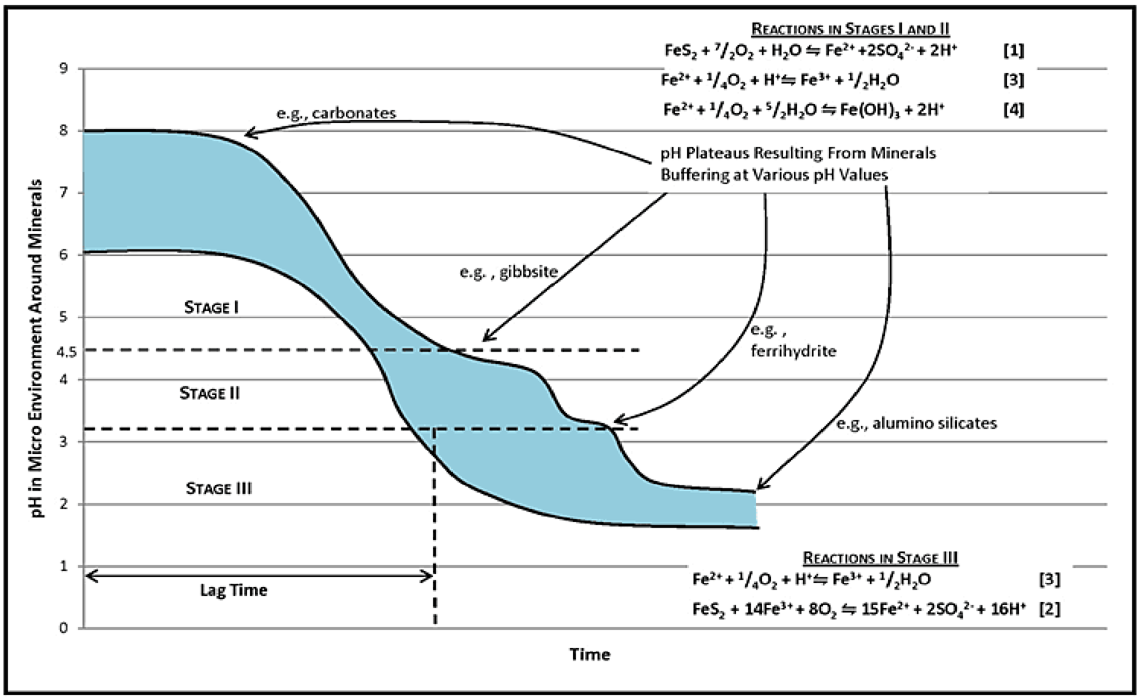
Although pyrite is by far the dominant sulfide responsible for the generation of acidity, different ore deposits contain different types of sulfide minerals. Not all of these sulfide minerals generate acidity when being oxidized. As a general rule, iron sulfides (pyrite, marcasite, pyrrhotite), sulfides with molar metal/sulfur ratios < 1, and sulfosalts (e.g., enargite) generate acid when they react with oxygen and water. Sulfides with metal/sulfur ratios = 1 (e.g., sphalerite, galena, chalcopyrite) tend not to produce acidity when oxygen is the oxidant. However, when aqueous ferric iron is the oxidant, all sulfides are capable of generating acidity. Therefore, the acid generation potential of an ore deposit or mine waste generally depends on the amount of iron sulfide present.

Neutralization reactions also play a key role in determining the compositional characteristics of drainage originating from sulfide oxidation. As for sulfide minerals, the reactivity, and accordingly the effectiveness with which neutralizing minerals are able to buffer any acid being generated, can vary widely. Most carbonate minerals are capable of dissolving rapidly, making them effective acid consumers. However, hydrolysis of dissolved Fe or Mn following dissolution of their respective carbonates and subsequent precipitation of a secondary mineral may generate acidity. Although generally more common than carbonate phases, aluminosilicate minerals tend to be less reactive, and their buffering may only succeed in stabilizing the pH when rather acidic conditions have been achieved. Calcium-magnesium silicates have been known to buffer mine effluents at neutral pH when sulfide oxidation rates were very low (Jambor, 2003).

The combination of acid generation and acid neutralization reactions typically leads to a step-wise development of ARD (Figure 4). Over time, pH decreases along a series of pH plateaus governed by the buffering of a range of mineral assemblages. The lag time to acid generation is a very important consideration in ARD prevention. It is far more effective (and generally far less costly in the long term) to control ARD generation during its early stages. The lag time also has significant ramifications for interpretation of test results. Because the first stage of ARD generation may last for a very long time, even for materials that will eventually be highly acid generating, it is critical to recognize the stage of oxidation when predicting ARD potential. The early results of geochemical testing, therefore, may not be representative of long-term environmental stability and associated discharge quality. However early test results provide valuable data to assess future conditions such as consumption rates of available neutralizing minerals.

A common corollary of sulfide oxidation is metal leaching (ML), leading to the frequent use of the acronyms "ARD/ML" or "ML/ARD" to more accurately describe the nature of acidic mine discharges. Major and trace metals in ARD, NMD, and SD originate from the oxidizing sulfides and dissolving acid-consuming minerals. In the case of ARD, Fe and Al are usually the principal major dissolved metals, while trace metals such as Cu, Pb, Zn, Cd, Mn, Co, and Ni can also achieve elevated concentrations. In mine discharges with a more circumneutral character, trace metal concentrations tend to be lower due to formation of secondary mineral phases and increased sorption. However, certain parameters remain in solution as the pH increases, in particular the metalloids As, Se, and Sb as well as other trace metals (e.g., Cd, Cr, Mn, Mo, and Zn).

Figure 4: Stages in the Formation of ARD (INAP, 2009)

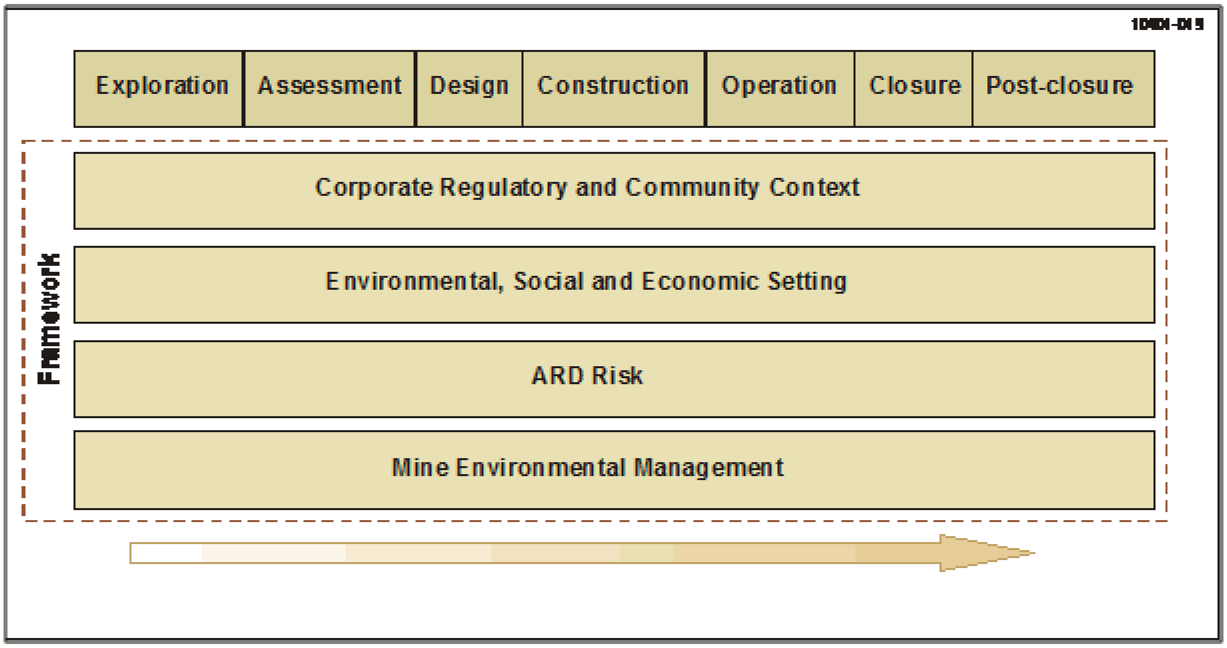


3 FRAMEWORK FOR ACID ROCK DRAINAGE MANAGEMENT

The issues and approaches to ARD prevention and management are the same around the world. However, the specific techniques used for ARD prediction, interpretation of ARD test results, and ARD management may differ depending on the local, regional or country context and are adapted to climate, topography, and other site conditions.

Therefore, despite the global similarities of ARD issues, there is no "one size fits all" approach to address ARD management. The setting of each mine is unique and requires a carefully considered assessment to find a management strategy within the broader corporate, regulatory and community framework that applies to the project in question. The site-specific setting comprises the social, economic and environmental situation within which the mine is located, whilst the framework comprises the applicable corporate, regulatory norms and standards and community specific requirements and expectations. This framework applies over the complete life cycle of the mine and is illustrated conceptually in Figure 5.

Figure 5: Conceptual ARD Management Framework (INAP, 2009)



All mining companies, regardless of size, need to comply with the national legislation and regulations pertaining to ARD of the countries within which they operate. It is considered good corporate practice to adhere to global ARD guidance as well, and in many cases such adherence is a condition of funding. Many mining companies have established clear corporate guidelines that represent the company's view of the priorities to be addressed and their interpretation of generally accepted best practice related to ARD. Caution is needed to ensure all specifics of the country regulations are met, as corporate ARD guidelines cannot be a substitute for country regulations.

Mining companies operate within the constraints of a "social license" that, ideally, is based on a broad consensus with all stakeholders. This consensus tends to cover a broad range of social, economic, environmental and governance elements (sustainable development). ARD plays an important part in the mine's social license due to the fact that ARD tends to be one of the more visible environmental consequences of mining. The costs of closure and post-closure management of ARD are increasingly recognized as a fundamental component of all proposed and operating mining operations. Some form of financial assurance is now required in many jurisdictions.

4 CHARACTERIZATION

The generation, release, transport and attenuation of ARD are intricate processes governed by a combination of physical, chemical and biological factors. Whether ARD becomes an environmental concern depends largely on the characteristics of the sources, pathways and receptors involved. Characterization of these aspects is therefore crucial to the prediction, prevention and management of ARD. Environmental characterization programs are designed to collect sufficient data to answer the following questions:

1 Is ARD likely to occur? What type of drainage is expected (ARD/NMD/SD)?
2 What are the sources of ARD? How much ARD will be generated and when?
3 What are the significant pathways that transport contaminants to the receiving environment?
4 What are the anticipated environmental impacts of ARD release to the environment?
5 What can be done to prevent or mitigate/manage ARD?

The geologic and mineralogic characteristics of the ore body and host rock are the principal controls on the type of drainage that will be generated as a result of mining. Subsequently, the site climatic and hydrologic/hydrogeologic characteristics define how mine drainage and its constituents are transported through the receiving environment to receptors. To evaluate these issues, expertise from multiple disciplines is required, including: geology, mineralogy, hydrology, hydrogeology, geochemistry, (micro)biology, meteorology, and engineering.

The geologic characteristics of mineral deposits exert important and predictable controls on the environmental signature of mineralized areas (Plumlee, 1999). Therefore, a preliminary assessment of the ARD potential should be made based on review of geologic data collected during exploration. Baseline characterization of metal concentrations in various environmental media (i.e., water, soils, vegetation and biota) may also provide an indication of ARD potential and serves to document potentially naturally elevated metal concentrations. During mine development and operation, the initial assessment of ARD potential is refined through detailed characterization data on the environmental stability of the waste and ore materials. The magnitude and location of mine discharges to the environment also are identified during mine development. Meteorologic, hydrological and hydrogeological investigations are conducted to characterize the amount and direction of water movement within the mine watershed(s) to evaluate transport pathways for constituents of interest. Potential biological receptors within the watershed boundary are identified. As a consequence, over the mine life, the focus of the ARD characterization program evolves from establishing baseline conditions, to predicting drainage release and transport, to monitoring of the environmental conditions and impacts.

Despite inherent differences at mine sites (e.g., based on commodity type, climate, mine phase, regulatory framework), the general approach to site characterization is similar:

- Define the quantity and quality of drainage potentially generated by different sources.
- Identify surface and groundwater pathways that transport drainage from sources to receptor.
- Identify receptors that may be affected by exposure to drainage Define the risk of this exposure.

Figures 6 and 7 present the chronology of an ARD characterization program and identify the data collection activities typically executed during each mine phase. The bulk of the characterization effort occurs prior to mining during the mine planning, assessment and design (sometimes collectively referred to as the development phase). In addition, potential environmental impacts are identified and appropriate prevention and mitigation measures, intended to minimize environmental impacts, are incorporated. During the commissioning/construction and operation phases, a transition from site characterization to monitoring occurs, which is continued throughout the decommissioning/closure and post-closure phases. Ongoing monitoring helps refine the understanding of the site, which allows for adjustment of remedial measures, in turn resulting in reduced closure costs and improved risk management.

Figure 6: Overview of ARD Characterization Program by Mine Phase (INAP, 2009)

Mine Phase – Increasing Knowledge of Site Characteristics

Conceptual Site Model Component

	Exploration	Mine Planning, Feasibility and Design (Development)	Construction and Commissioning	Operation	Decommissioning	Post-Closure
Source	Ore body characterization	Laboratory testing of waste and ore materials (static and kinetic) Collection and analysis of water samples from existing historic sources	Ongoing laboratory testing Field testing of waste and ore materials	Ongoing laboratory and field testing Instrumentation of waste facilities Collection and analysis of water samples from sources	Ongoing water quality monitoring	Long-term water quality monitoring (if necessary)
Pathway	Exploration drilling may characterize groundwater occurrence	Hydrogeologic characterization - groundwater occurrence, direction and rate of flow Hydrologic characterization - surface water flow Baseline surface water and groundwater quality Baseline soil and sediment quality	Hydrogeologic, hydrologic and water quality monitoring	Ongoing hydrogeologic, hydrologic and water quality monitoring	Ongoing hydrogeologic, hydrologic and water quality monitoring	Ongoing hydrogeologic, hydrologic and water quality monitoring (if necessary)
Receptor		Receptor identification Baseline characterization (receptors and habitat including vegetation metals surveys)	Receptor and habitat monitoring	Ongoing receptor and habitat monitoring	Ongoing receptor and habitat monitoring	Ongoing receptor and habitat monitoring (if necessary)
	Ore body information supports site and source characterization	**Peak Characterization Effort**	**Ongoing Characterization and Monitoring**			

Figure 7: ARD Characterization Program for Individual Source Materials by Mine Phase (INAP, 2009)

Mine Phase – Increasing Knowledge of Source Material Characterization

Waste or Facility Type – Potential ARD / NMD / SD Sources

	Exploration	Mine Planning, (Pre-) Feasibility and Design	Construction and Commissioning	Operation	Decommissioning	Post-Closure (Care and Maintenance)
Waste Rock	Drill core descriptions and assay data (petrology and mineralogy) Block model (quantity of ore and waste)	Laboratory testing of drill core samples – sample selection targets waste [a]	Ongoing laboratory testing of drill core or development rock samples [a] Field leach testing (barrels, test pads)	Ongoing laboratory testing [a] Ongoing field leach testing Collection and analysis of runoff and seepage samples from waste rock facility	Collection and analysis of runoff and seepage samples from waste rock facility	Collection and analysis of runoff and seepage samples from waste rock facility (if necessary)
Tailings	Review of any historical data	Laboratory testing of pilot plant tailings [a] Analysis of pilot testing supernatant.	Ongoing laboratory testing of pilot plant tailings [a]	Ongoing laboratory testing of tailings discharge [a] Collection and analysis of supernatant and seepage samples from TSF	Collection and analysis of supernatant and seepage samples from TSF	Collection and analysis of supernatant and seepage samples from TSF (if necessary)
Ore		Laboratory testing of drill core samples [a]		Ongoing laboratory testing [a]	If ore stockpiles exist, collection and analysis of runoff and seepage samples	
Pit		Laboratory testing of drill core samples – sample selection targets pit walls [a]		Field scale leach testing (e.g., wall washing) Collection and analysis of water samples (i.e., runoff, sumps)	Collection and analysis of pit water and pit inflow(s) water samples	Collection and analysis of pit water samples (if necessary)
Under-ground Workings		Laboratory testing of drill core samples – sample selection targets mine walls [a]		Collection and analysis of water samples (i.e., sumps, dewatering wells)	Collection and analysis of mine pool water samples	Collection and analysis of mine pool water samples (if necessary)

[a] Typical laboratory testing components: particle size, whole rock analysis, mineralogy, ABA, static and kinetic leach testing.

5 PREDICTION

One of the main objectives of site characterization is prediction of ARD potential and drainage chemistry. Because prediction is directly linked to mine planning, in particular with regard to water and mine waste management, the characterization effort needs to be phased in step with overall project planning. Early characterization tends to be generic and generally avoids presumptions about the future engineering/mine design, while later characterization and modeling must consider and be integrated with the specifics of engineering/mine design. Iteration may be required as evaluation of the ARD potential may result in the realization that a re-assessment of the overall mine plan is needed. Integration of the characterization and prediction effort into the mine operation is a key element for successful ARD management.

Accurate prediction of future mine discharges requires an understanding of the sampling, testing, and analytical procedures used, consideration of the future physical and geochemical conditions, and the identity, location and reactivity of the contributing minerals. All mine sites are unique for reasons related to geology, geochemistry, climate, commodity, processing method, regulations and stakeholders. Prediction programs therefore need to be tailored to the mine in question. Also, the objectives of a prediction program can be variable. For instance, they can include definition of water treatment requirements, selection of mitigation methods, assessment of water quality impact, or determination of reclamation bond amounts.

Predictions of drainage quality are made in a qualitative and quantitative sense. Qualitative predictions are focused on assessing whether acidic conditions might develop in mine wastes, with the corresponding release of metals and acidity to mine drainage. Where qualitative predictions indicate a high probability of ARD generation, attention turns to review of alternatives to prevent ARD and the prediction program is refocused to assist in the design and evaluation of these alternatives.

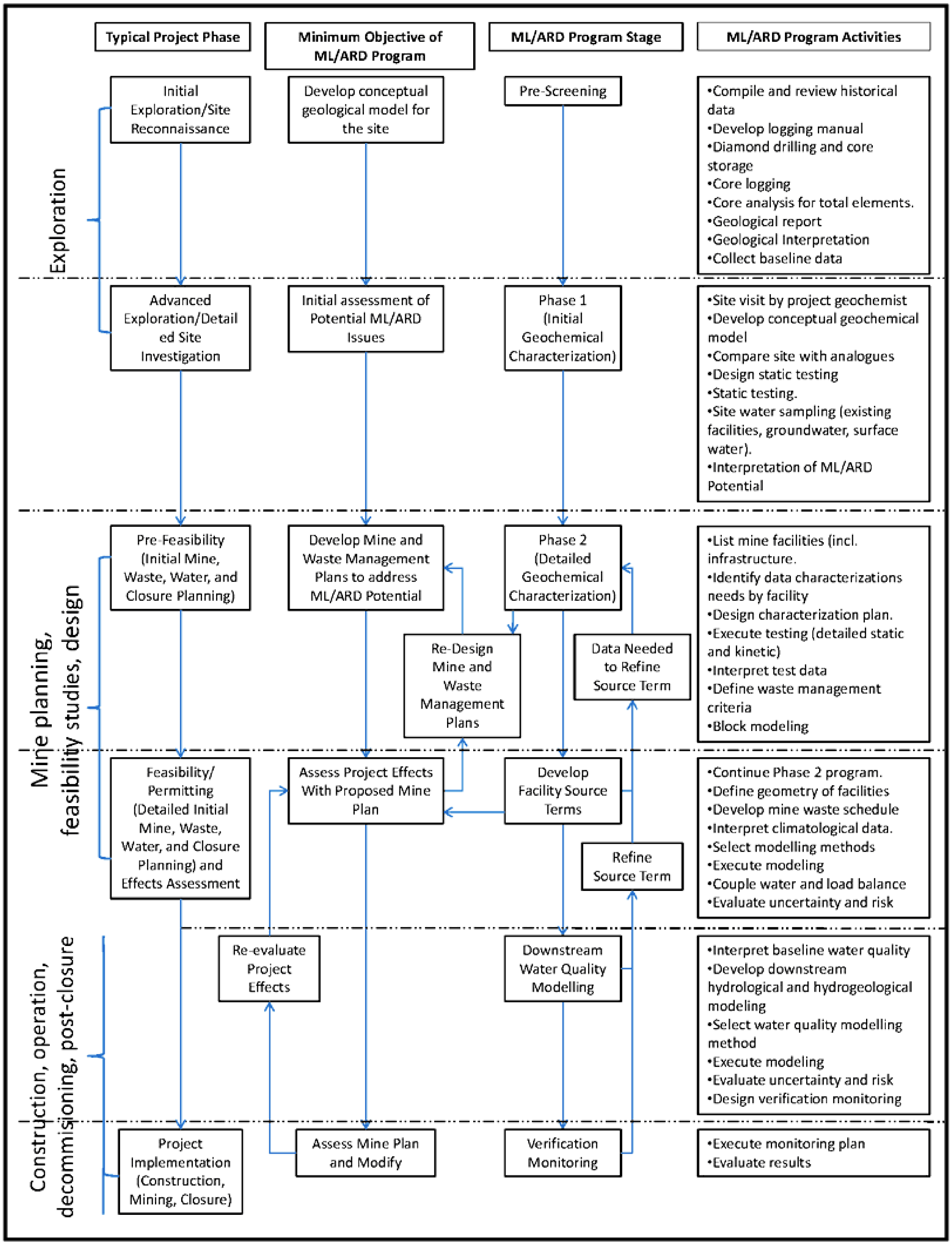
Significant advances in the understanding of ARD have been made over the last several decades, with parallel advances in mine water quality prediction and use of prevention techniques. However, quantitative mine water quality prediction can be challenging due to the wide array of the reactions involved and potentially very long time periods over which these reactions take place. Despite these uncertainties, quantitative predictions that have been developed using realistic assumptions (while recognizing associated limitations) have proven to be of significant value for identification of ARD management options and assessment of potential environmental impacts.

Prediction of mine water quality generally is based on one of more of the following:

1. Test leachability of waste materials in the laboratory.
2. Test leachability of waste materials under field conditions
3. Geological, hydrological, chemical and mineralogical characterization of waste materials
4. Geochemical and other modeling

Analog operating or historic sites are also valuable in ARD prediction, especially those that have been thoroughly characterized and monitored. The development of geo-environmental models is one of the more prominent examples of the “analog” methodology. Geo-environmental models, which are constructs that interpret the environmental characteristics of an ore deposit in a geologic context, provide a very useful way to interpret and summarize the environmental signatures of mining and mineral deposits in a systematic geologic context, and can be applied to anticipate potential environmental problems at future mines, operating mines and orphan sites (Plumlee et al., 1999). A generic overall approach for ARD prediction is illustrated in Figure 8.

Figure 8: Generic Overview of ARD Prediction Approach (INAP, 2009)



6 PREVENTION AND MITIGATION

The fundamental principle of ARD prevention is to apply a planning and design process to prevent, inhibit, retard or stop the hydrological, chemical, physical, or microbiological processes that result in the impacts to water resources. Prevention should occur at, or as close to, the point where the deterioration in water quality originates (i.e. source reduction), or through implementation of measures to prevent or retard the transport of the ARD to the water resource (i.e. recycling, treatment and/or secure disposal). This principle is universally applicable, but methods of implementation are site specific.

Prevention is a proactive strategy that obviates the need for the reactive approach to mitigation. For an existing case of ARD that is adversely impacting the environment, mitigation will usually be the initial course of action. Despite this initial action, subsequent preventive measures are often considered with the objective of reducing future contaminant loadings, and thus reducing the ongoing need for mitigation controls. Integration of the prevention and mitigation effort into the mine operation is a key element for successful ARD management.

Prior to identification of evaluation of prevention and mitigation measures, the strategic objectives must be identified. That process should consider assessment of the following:

- Quantifiable risks to ecological systems, human health, and other receptors;
- Site specific discharge water quality criteria;
- Capital, operating and maintenance costs of mitigation or preventative measures;
- Logistics of long-term operations and maintenance; and
- Required longevity and anticipated failure modes

Typical objectives for ARD control are to satisfy environmental criteria using the most cost-effective technique. Technology selection should consider predictions for discharge water chemistry, advantages and disadvantages of treatment options, risk to receptors, and the regulatory context related to mine discharges.

A risk-based planning and design approach forms the basis for prevention and mitigation. This approach is applied throughout the mine life cycle, but primarily in the assessment and design phases. The risk-based process aims to quantify the long-term impacts of alternatives and to use this knowledge to select the option that has the most desirable combination of attributes (e.g., protectiveness, regulatory acceptance, community approval, cost). Mitigation measures implemented as part of an effective control strategy should require minimal active intervention and management.

Prevention is the key to avoid costly mitigation. The primary objective is to apply methods that minimize sulfide reaction rates, metal leaching and the subsequent migration of weathering products that result from sulfide oxidation. Such methods involve:

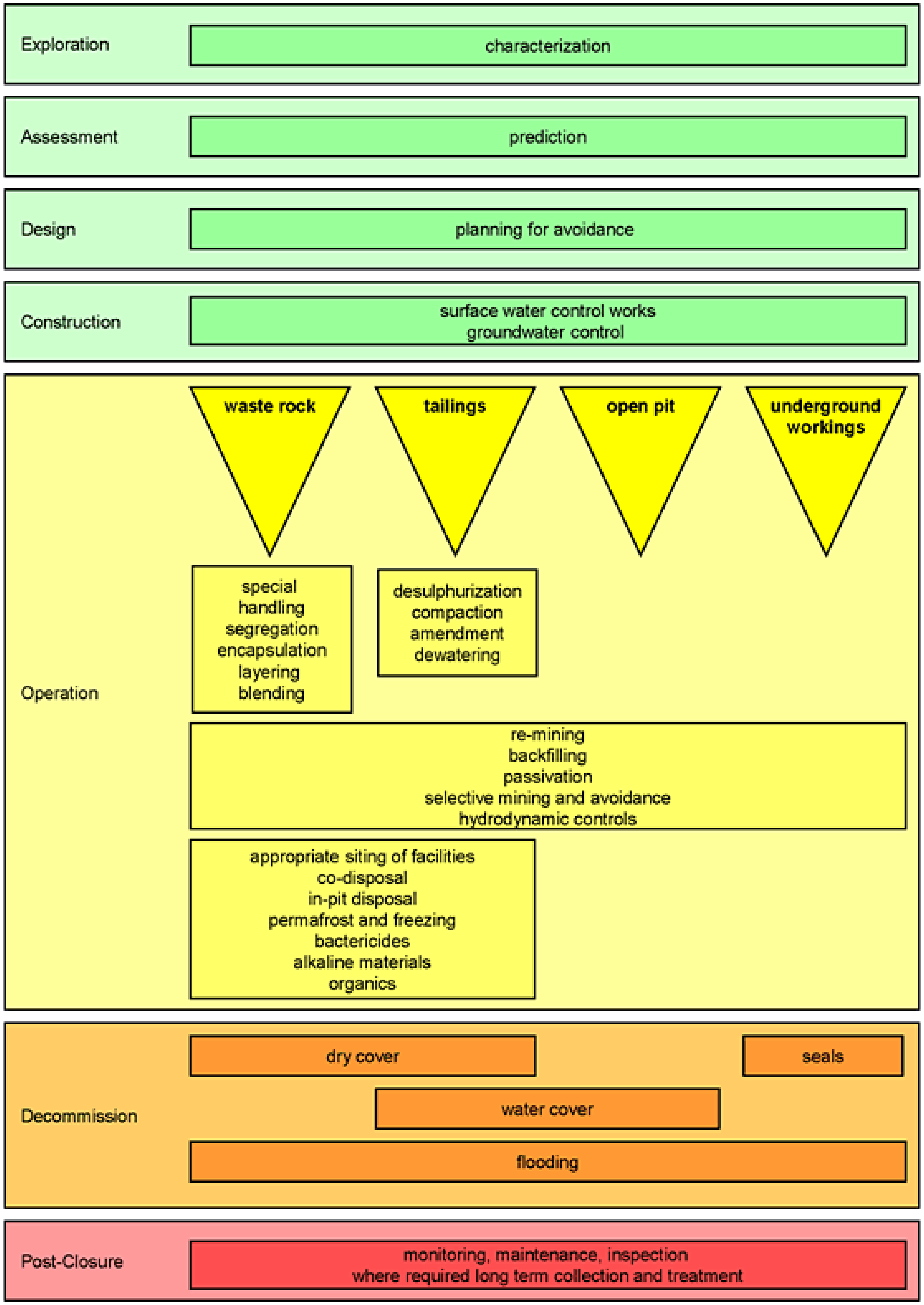
- Minimizing oxygen supply
- Minimizing water infiltration and leaching
- Minimizing, removing or isolating sulfide minerals
- Controlling pore water solution pH
- Controlling bacteria and biogeochemical processes

Factors influencing selection of the above methods include:

1. Geochemistry of source materials and the potential of source materials to produce ARD;
2. Type and physical characteristics of the source, including water flow and oxygen transport;Mine-development stage (more options are available at early stages);
3. Phase of oxidation (more options are available at early stages when pH is still near neutral and oxidation products have not significantly accumulated);
4. Time period for which the control measure is required to be effective;
5. Site conditions (i.e., location, topography and available mining voids, climate, geology, hydrology and hydrogeology, availability of materials and vegetation); and
6. Water quality criteria for discharge; and Risk acceptance by company and other stakeholders.

More than one, or a combination of measures, may be required to achieve the desired objective. Figure 9 provides a generic overview of the most common ARD prevention and mitigation measures available during the various stages of the mine-life cycle.

Figure 9: Generic Overview of ARD Prevention and Mitigation Measures (INAP, 2009)



7 ACID ROCK DRAINAGE TREATMENT

Sustainable mining requires the mitigation, management and control of mining impacts on the environment. The impacts of mining on water resources can be long term and persist in the post-closure situation. Mine drainage treatment may be a component of overall mine water management to support a mining operation over its entire life. The objectives of mine drainage treatment are varied. Recovery and re-use of mine water within the mining operations may be desirable or required for processing of ores and minerals, conveyance of materials, operational use (dust suppression, mine cooling, irrigation of rehabilitated land), etc. Mine drainage treatment, in this case, is aimed at modifying the water quality so that it is fit for the intended use on or off the mine site.

Another objective of mine water treatment is the protection of human and ecological health in cases where people or ecological receptors may come in contact with the impacted mine water through indirect or direct use. Mine drainage may act as the transport medium for a range of pollutants, which may impact on-site and off-site water resources. Water treatment would remove the pollutants contained in mine drainage to prevent or mitigate environmental impacts.

In the large majority of jurisdictions, any discharge of mine drainage to a public stream or aquifer must be approved by the relevant regulatory authorities, while regulatory requirements stipulate a certain mine water discharge quality or associated discharge pollutant loads. Although discharge quality standards may not be available for many developing mining countries, internationally acceptable environmental quality standards generally still apply as stipulated by project financiers and company corporate policies.The approach to selection of a mine drainage treatment method is premised on a thorough understanding of the integrated mine water system and circuits and the specific objective(s) to be achieved. The approach adopted for mine drainage treatment will be influenced by a number of considerations.

Prior to selecting the treatment process, a clear statement and understanding of the objectives of treatment should be prepared. Mine drainage treatment must always be evaluated and implemented within the context of the integrated mine water system. Treatment will have an impact on the flow and quality profile in the water system; hence, a treatment system is selected based on mine water flow, water quality, cost and ultimate water use(s).

Characterization of the mine drainage in terms of flow and chemical characteristics should include due consideration of temporal and seasonal changes. Flow data are especially important as this information is required to properly size any treatment system. Of particular importance are extreme precipitation and snow melt events that require adequate sizing of collection ponds and related piping and ditches. The key chemical properties of mine drainage relate to acidity/alkalinity, sulfate content, salinity, metal content, and the presence of specific compounds associated with specific mining operations, such as cyanide, ammonia, nitrate, arsenic, selenium, molybdenum and radionuclides. There are also a number of mine drainage constituents (for example, hardness, sulfate, silica) which may not be of regulatory or environmental concern in all jurisdictions, but that could affect the selection of the preferred water treatment technology. Handling and disposal of treatment plant waste and residues such as sludges and brines and their chemical characteristics must also factor in any treatment decisions.

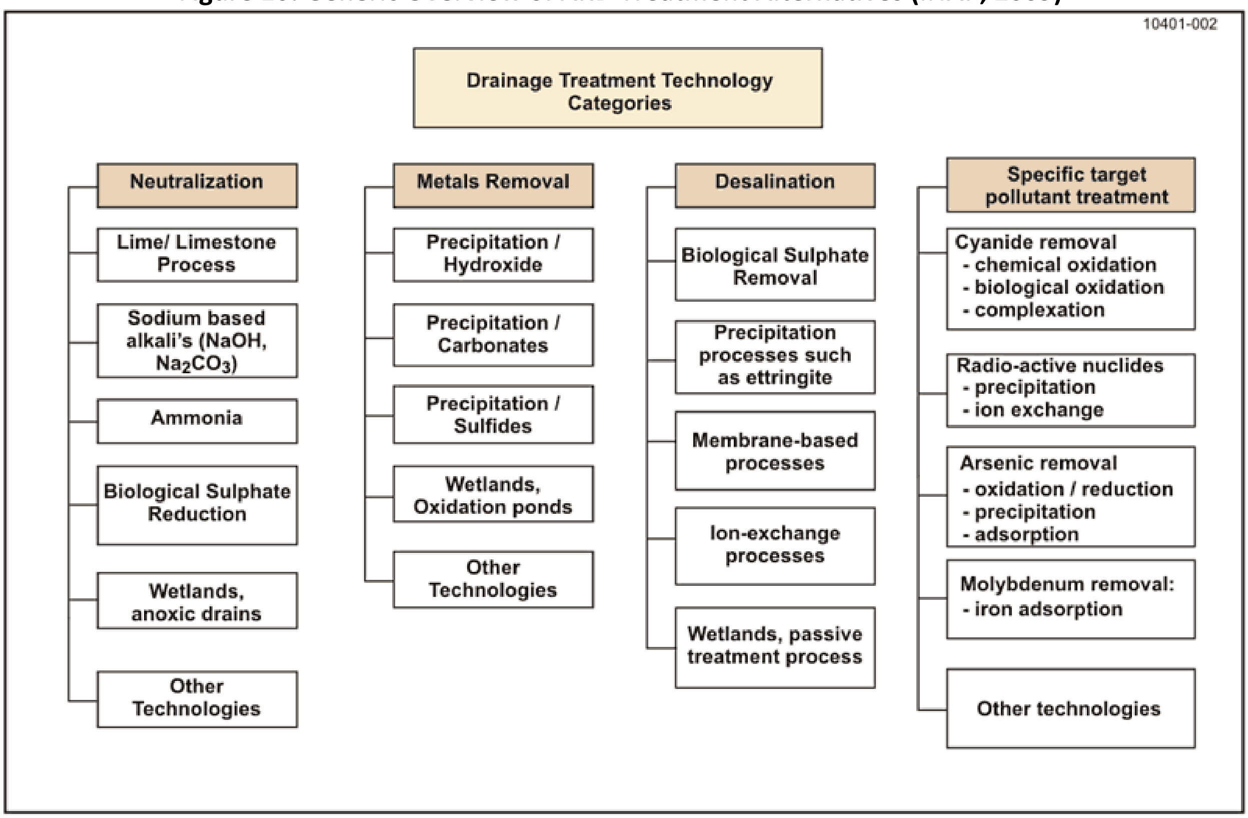
A mine-drainage treatment facility must have the flexibility to deal with increasing/decreasing water flows, changing water qualities and regulatory requirements over the life of mine. This may dictate phased implementation and modular design and construction. Additionally, the post-closure phase may place specific constraints on the continued operation and maintenance of a treatment facility.

Practical considerations related to mine-site features that will influence the construction, operation and maintenance of a mine-drainage-treatment facility are as follows:

- Mine layout and topography
- Space
- Climate
- Sources of mine drainage feeding the treatment facility
- Location of treated water users

A generic range of ARD treatment alternatives is presented in Figure 10.

Figure 10: Generic Overview of ARD Treatment Alternatives (INAP, 2009)

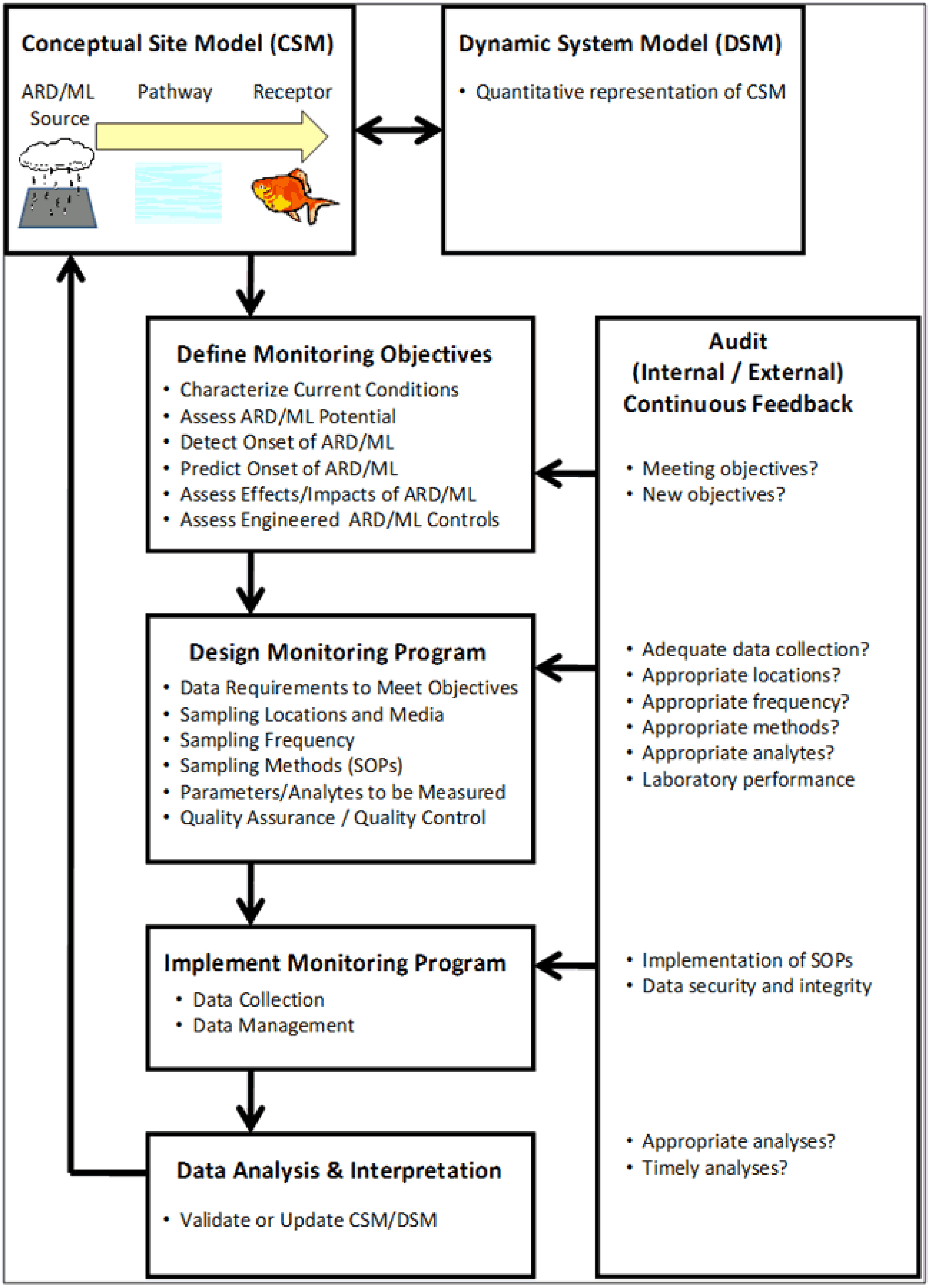


8 ACID ROCK DRAINAGE MONITORING

Monitoring is the process of routinely, systematically and purposefully gathering information for use in management-decision making. Mine-site monitoring aims to identify and characterize any environmental changes from mining activities to assess conditions on the site and possible impacts to receptors. Monitoring consists of both observation (e.g., recording information about the environment) and investigation (e.g., studies such as toxicity tests where environmental conditions are controlled). Monitoring is critical in decision making related to ARD management, for instance through assessing the effectiveness of mitigation measures and subsequent implementation of adjustments to mitigation measures as required.

Development of an ARD monitoring program starts with review of the mine plan, the geographical location and the geological setting. The mine plan provides information on the location and magnitude of surface and subsurface disturbances, ore processing and milling procedures, waste disposal areas, effluent discharge locations, groundwater withdrawals and surface water diversions. This information is used to identify potential sources of ARD, potential pathways for release of ARD to the receiving environment, and receptors that may be impacted by these releases and potential mitigation that may be required. Because the spatial extent of a monitoring program must include all these components, a watershed approach to ARD monitoring (including groundwater) is often required. Monitoring occurs at all stages of project development, from pre-operational through post closure. However, over the life of a mine, the objectives, components and intensity of the monitoring activities will change. The development and components of a generic ARD monitoring program are presented in Figure 11.

Figure 11: Development of an ARD Monitoring Program (INAP, 2009)



9 ACID ROCK DRAINAGE MANAGEMENT AND PERFORMANCE ASSESSMENT

The management of ARD and the assessment of its performance are usually described within the site environmental management plan or in a site-specific ARD management plan. The ARD management plan represents the integration of the concepts and technologies described earlier in this chapter. It also references the engineering design processes and operational management systems employed by mining companies.

The need for a formal ARD management plan is usually triggered by the results of an ARD characterization and prediction program or the results of site monitoring. The development, assessment and continuous improvement of an ARD management plan is a continuum throughout the life of a mine. The development, implementation and assessment of the ARD management plan will typically follow the sequence of steps illustrated in Figure 12. As shown in this figure, the development of an ARD management plan starts with establishment of clear goals and objectives. These might include the prevention of ARD or achieving compliance with specific water quality criteria. This includes consideration of the biophysical setting, regulatory and legal registry, community and corporate requirements and financial considerations. Characterization and prediction programs identify the potential magnitude of the ARD issue and provide the basis for the selection and design of appropriate ARD prevention and mitigation technologies. The design process includes an iterative series of steps in which ARD control technologies are assessed and then combined into a robust system of management and controls (i.e., the ARD management plan) for the specific site. The initial mine design may be used to develop the ARD management plan needed for an environmental assessment (EA). The final design is usually developed in parallel with project permitting.

The ARD management plan identifies the materials and mine wastes that require special management. Risk assessment and management are included in the plan to refine strategies and implementation steps. To be effective, the ARD management plan must be fully integrated with the mine plan. Operational controls such as standard operating procedures (SOPs), key performance indicators (KPIs) and quality assurance/quality control (QA/QC) programs are established to guide its implementation. The ARD management plan identifies roles, responsibilities and accountabilities for mine operating staff. Data management, analysis and reporting schemes are included to track progress of the plan.

In the next step, monitoring is conducted to compare field performance against the design goals and objectives of the management plan. Assumptions made in the characterization and prediction programs and design of the prevention/mitigation measures are tested and revised or validated. “Learnings” from monitoring and assessment are evaluated and incorporated into the plan as part of continuous improvement.

Accountability for implementing the management plan is checked to ensure that those responsible are meeting the requirements stipulated in the plan. Internal and external reviews or audits should be conducted to gauge performance of personnel, management systems, and technical components to provide additional perspectives on the implementation of the ARD management plan. Review by site and corporate management of the entire plan is necessary to ensure the plan continues to adhere to site and corporate policies. Additional risk assessment and management may be conducted at this stage to assess the effects of changing conditions or plan deviations. Finally, results are assessed against the goals. If the objectives are met, performance assessment and monitoring continues throughout the mine life with periodic re-checks against the goals. If the objectives are not met, then re-design and re-evaluation of the management plan and performance assessment and monitoring systems for ARD prevention/mitigation are required. This additional effort might also require further characterization and ARD prediction.

The process described in Figure 12 results in continuous improvement of the ARD management plan and its implementation, and accommodates possible modifications in the mine plan. If the initial ARD management plan is robust, it can be more readily adapted to mine plan changes.

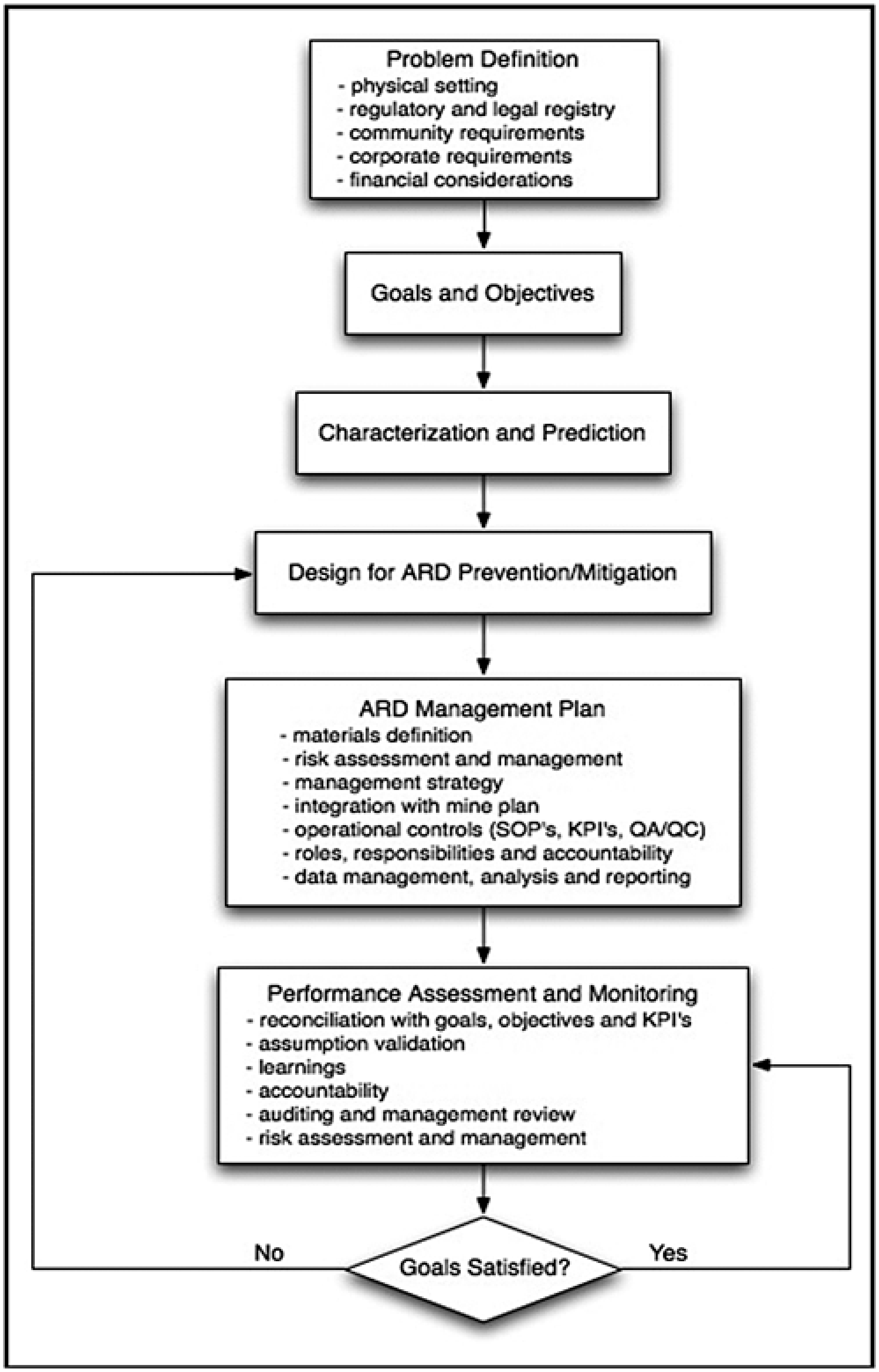
Implementing the ARD management plan relies on a hierarchy of management tools. Corporate policies help define corporate or site standards which lead to SOPs and KPIs that are specific to the site and guide operators in implementing the ARD management plan. Where corporate policies or standards do not exist, projects and operations should rely on industry best practice.

10 ACID ROCK DRAINAGE COMMUNICATION AND CONSULTATION

The level of knowledge of ARD generation and mitigation has increased dramatically over the last few decades within the mining industry, academia and regulatory agencies. However, in order for this knowledge to be meaningful to the wide range of stakeholders generally involved with a mining project, it needs to be translated into a format that can be readily understood. This consultation should convey the predictions of future drainage quality and the effectiveness of mitigation plans, their degree of certainty and contingency measures to address that uncertainty. An open dialogue on what is known, and what can be predicted with varying levels of confidence, helps build understanding and trust, and ultimately results in a better ARD management plan.

Communicating and consulting with stakeholders about ARD issues is essential to the company's social license to operate. Due to the generally highly visible nature of ARD, special measures and skilled people are needed to communicate effectively, and the involvement of representatives from all relevant technical disciplines in a mining company may be required.

Figure 12: Flow Chart for ARD Performance Assessment and Management Review (INAP, 2009)



11 SUMMARY

Acid rock drainage is one of the most serious environmental issues facing the mining industry. A thorough evaluation of ARD potential should be conducted prior to mining and continued through the life of mine. Consistent with sustainability principles, strategies for dealing with ARD should focus on prevention or minimization rather than control or treatment. These strategies are formulated within an ARD management plan, to be developed in the early phases of the project, together with monitoring requirements to assess their performance. The integration of the ARD management plan with the mine operation plan is critical to the success of ARD prevention. Leading practices for ARD management continue to evolve, but tend to be site specific and require specialist expertise.

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APPENDIX F. SAMPLING AND ANALYSIS PLAN

GUIDANCE AND TEMPLATE

VERSION 2, PRIVATE ANALYTICAL SERVICES USED
R9QA/002.1
April, 2000

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 9
http://ndep.nv.gov/BCA/file/reid_sap.pdf

This Sampling and Analysis Plan (SAP) guidance and template is based USEPA guidance as presented http://ndep.nv.gov/BCA/file/reid_sap.pdf . It is intended assist organization in documenting the procedural and analytical requirements for baseline and routine monitoring of surface water ground water, soils, and biological samples. It has originally developed to characterize contaminated land but has been modified here to address sampling, laboratory analysis, and quality control/quality assurance for evaluation pre-mining, mining, and post mining hydrologic and biologic conditions. This guide is to be used as a template. It provides item-by-item instructions for creating a SAP and includes example language which can be used with or without modification.

1 INTRODUCTION

[This section should include a brief description of the project, including the history, problem to be investigated, scope of sampling effort, and types of analyses that will be required. These topics will be covered in depth later so do not include a detailed discussion here.]

1.1 SITE NAME OR SAMPLING AREA

[Provide the most commonly used name of the site or sampling area.]

Site or Sampling Area Location

[Provide a general description of the region, or district in which the site or sampling area is located. Detailed sampling location information should be provided later in Section 2]

1.2 RESPONSIBLE ORGANIZATION

[Provide a description of the organization conducting the sampling.]

1.3 PROJECT ORGANIZATION

[Provide the name and phone number(s) of the person(s) and/or contractor working on the sampling project as listed in the table. The table can be modified to include titles or positions appropriate to the specific project. Delete personnel or titles not appropriate to the project]

Title/Responsibility Name Phone Number
Project Manager
Staff

Quality Assurance Manager
Contractor (Company Name)
Contractor Staff

1.4 STATEMENT OF THE SPECIFIC PROBLEM

[In describing the problem, include historical, as well as recent, information and data that may be relevant. List and briefly outline citizens' complaints, public agency inspections, and existing data. Include sources of information if possible.]

2 BACKGROUND

This section provides an overview of the location of, previous investigations of, and the apparent problem(s) associated with the site or sampling area. [Provide a brief description of the site or sampling area, including chemicals used on the site, site history, past and present operations or activities that may have contributed to the suspected contamination, etc.]

2.1 SITE OR SAMPLING AREA DESCRIPTION [FILL IN THE BLANKS.]

[Two maps of the area should be provided: the first (Figure 2.1), on a larger scale, should place the area within its geographic region; the second (Figure 2.2), on a smaller scale, should mark the sampling site or sampling areas within the local area. Additional maps may be provided, as necessary, for clarity. Maps should include a North arrow, groundwater flow arrow (if appropriate), buildings or former buildings, area to be mine, permit area, area to be disturbed, etc. If longitude or latitude information is available, such as from a Global Positioning System (GPS), provide it. Sampling locations can be shown in Figure 2.2.]. Example language is as follows:

The site or sampling area occupies __________ [e.g., hectares or square meters] in a ________________ [e.g., urban, commercial, industrial, residential, agricultural, or undeveloped] area. The site or sampling area is bordered on the north by ___________, on the west by ______________, on the south by ________________, and on the east by ________________. The specific location of the site or sampling area is shown in Figure 2.2.

____
____
____
____
____

The second paragraph (or set of paragraphs) should describe historic and current on-site structures and should be consistent with what is presented in Figure 2.2.

2.2 OPERATIONAL HISTORY

[As applicable, describe in as much detail possible (i.e., use several paragraphs) the past and present activities at the site or sampling area. The discussion might include the following information:

- **A description of the owner(s) and/or operator(s) of the site or areas near the site, the watershed of interest, the sampling area, etc. (present this information chronologically);**
- **A description of past and current operations or activities that may have contributed to suspected contamination of the sit;**
- **A description of the processes involved in the operation(s) and the environmentally detrimental substances, if any, used in the processes;**
- **A description of any past and present waste management practices.**

- **If a waste site, were/are hazardous wastes generated by one or more of the processes described earlier? If so, what were/are they, how and where were/are they stored on the site or sampling area, and where were/are they ultimately disposed of? If an ecosystem, what point and non-point sources which may have affected the river, stream, lake or watershed?]**

2.3 PREVIOUS INVESTIGATIONS/REGULATORY INVOLVEMENT

[If applicable] [Summarize all previous sampling efforts at the site or sampling area. Include the sampling date(s); name of the party (ies) that conducted the sampling; local, regional, or federal government agency for which the sampling was conducted; a rationale for the sampling; the type of media sampled (e.g., soil, sediment, water); laboratory methods that were used; and a discussion of what is known about data quality and usability. The summaries should be presented in subsections according to the media that were sampled (e.g., soil, water, etc.) and chronologically within each medium. Attach reports or summary tables of results or include in appendices if necessary.]

2.4 GEOLOGICAL INFORMATION

[Groundwater sampling only][Provide a description of the hydrogeology of the area. Indicatethe direction of groundwater flow, if known.]

2.5 ENVIRONMENTAL AND/OR HUMAN IMPACT

[Discuss what is known about the possible and actual impacts of the possible environmental problem on human health or the environment.]

3 PROJECT DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and quantitative statements for establishing criteria for data quality and for developing data collection designs.

3.1 PROJECT TASK AND PROBLEM DEFINITION

[Describe the purpose of the environmental investigation in qualitative terms and how the data will be used. Generally, this discussion will be brief and generic. Include all measurements to be made on an analyte specific basis in whatever medium (soil, sediment, water, etc.) is to be sampled. This discussion should relate to how this sampling effort will support the specific decisions described in Section 3.2.]

3.2 DATA QUALITY OBJECTIVES (DQOS)

Data quality objectives (DQOs) are quantitative and qualitative criteria that establish the level of uncertainty associated with a set of data. This section should describe decisions to be made based on the data and provide criteria on which these decisions will be made.

[Discuss Data Quality Objectives, action levels, and decisions to be made based on the data here.]

3.3 DATA QUALITY INDICATORS (DQIS)

Data quality indicators (accuracy, precision, completeness, representativeness, comparability, and method detection limits) refer to quality control criteria established for various aspects of data gathering, sampling, or analysis activity. In defining DQIs specifically for the project, the level of *uncertainty associated with each measurement is defined. Definition of the different terms are provided below:*

- *Accuracy is the degree of agreement of a measurement with a known or true value. To determine accuracy, a laboratory or field value is compared to a known or true concentration. Accuracy is determined by such QC indicators as: matrix spikes, surrogate spikes, laboratory control samples (blind spikes) and performance samples.*
- *Precision is the degree of mutual agreement between or among independent measurements of a similar property (usually reported as a standard deviation [SD] or relative percent difference [RPD]). This indicator relates to the analysis of duplicate laboratory or field samples. An RPD of <20% for water and <35% for soil, depending upon the chemical being analyzed, is generally acceptable. Typically field precision is assessed by co-located samples, field duplicates, or field splits and laboratory precision is assessed using laboratory duplicates, matrix spike duplicates, or laboratory control sample duplicates).*
- *Completeness is expressed as percent of valid usable data actually obtained compared to the amount that was expected. Due to a variety of circumstances, sometimes either not all samples scheduled to be collected can be collected or else the data from samples cannot be used (for example, samples lost, bottles broken, instrument failures, laboratory mistakes, etc.). The minimum percent of completed analyses defined in this section depends on how much information is needed for decision making. Generally, completeness goals rise the fewer the number of samples taken per event or the more critical the data are for decision making. Goals in the 75-95% range are typical.*
- *Representativeness is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. It relates bothto the area of interest and to the method of taking the individual sample. The idea of representativeness should be incorporated into discussions of sampling design. Representativeness is best assured by a comprehensive statistical sampling design, but it is recognized that is usually outside the scope of most one-time events. Most one time SAPs should focus on issues related to judgmental sampling and why certain areas are included or not included and the steps being taken to avoid either false positives or false negatives.*
- *Comparability expresses the confidence with which one data set can be compared to another. The use of methods from EPA or "Standard Methods" or from some other recognized sources allows the data to be compared facilitating evaluation of trends or changes in a site, a river, groundwater, etc. Comparability also refers to the reporting of data in comparable units so direct comparisons are simplified (e.g., this avoids comparison of mg/L for nitrate reported as nitrogen to mg/L of nitrate reported as nitrate, or ppm vs. mg/L discussions).*
- *Detection Limit(s) (usually expressed as method detection limits for all analytes or compounds of interest for all analyses requested must be included in this section. These limits should be related to any decisions that will be made as a result of the data collection effort. A critical element to be addressed is how these limits relate to any regulatory or action levels that may apply.*

DQI tables are available from the QA Office for most routinely ordered methods. These tables can be attached to the SAP and referenced in this section. If an organization, its contractor, or its laboratory wish to use different limits or acceptance criteria, the table should be modified accordingly. SOPs should be included for methods not covered by the DQI tables or they can be submitted in lieu of the tables. Due to resource constraints, generally only the DQI aspects of these SOPs will be evaluated.

[Provide or reference DQI tables here]

3.4 DATA REVIEW AND VALIDATION

This section should discuss data review, including what organizations or individuals will be responsible for what aspects of data review and what the review will include.

[Discuss data review and data validation here including what organizations or individuals will be responsible for what aspects of data review and what the review will include. This section should also discuss how data that do not meet data quality objectives will be designated, flagged, or otherwise handled. Possible corrective actions associated with the rejection of data, such as reanalysis, resampling, no action but monitor the data more closely next quarter, etc., also need to be addressed]

3.5 DATA MANAGEMENT

[Provide a list of the steps that will be taken to ensure that data are transferred accurately from collection to analysis to reporting. Discuss the measures that will be taken to review the data collection processes, including field notes or field data sheets; to obtain and review complete laboratory reports; and to review the data entry system, including its use in reports. A checklist is acceptable.]

3.6 ASSESSMENT OVERSIGHT

[Describe the procedures which will be used to implement the QA Program. This would include oversight by the Quality Assurance Manager or the person assigned QA responsibilities. Indicate how often a QA review of the different aspects of the project, including audits of field and laboratory procedures, use of performance samples, review of laboratory and field data, etc., will take place. Describe what authority the QA Manager or designated QA person has to ensure that identified field and analytical problems will be corrected and the mechanism by which this will be accomplished.]

4 SAMPLING RATIONALE

For each sampling event, the SAP must describe the sampling locations, the media to be sampled, and the analytes of concern at each location. A rationale should then be provided justifying these choices. The following sections are subdivided on a media specific basis among soil, sediment, water, and biological media. Other media should be added as needed. This section is crucial to plan approval and should be closely related to previously discussed DQOs.

4.1 SOIL SAMPLING

[Provide a general overview of the soil sampling event. Present a rationale for choosing each sampling location at the site or sampling area and the depths at which the samples are to be taken, if relevant. If decisions will be made in the field, provide details concerning the criteria that will be used to make these decisions (i.e., the decision tree to be followed). List the analytes of concern at each location and provide a rationale for why the specific chemical or group of chemicals (e.g., trace metals etc) were chosen. Include sampling locations in Figure 2.2 or equivalent.]

4.2 SEDIMENT SAMPLING

[Provide a general overview of the sediment sampling event. Present a rationale for choosing each sampling location at the site or sampling area and the depths or area of the river, stream or lake at which the samples are to be taken, if relevant. If decisions will be made in the field, provide details concerning the criteria that will be used to make these decisions (i.e., the decision tree to be followed). List the analytes of concern at each location and provide a rationale for why the specific

chemical or group of chemicals (e.g., trace metals) were chosen. Include sampling locations in Figure 2.2 or equivalent.]

4.3 WATER SAMPLING

[Provide a general overview of the water sampling event. For groundwater, describe the wells to be sampled or how the samples will be collected (e.g., hydro punch), including the depths at which the samples are to be taken. For surface water, describe the depth and nature of the samples to be collected (fast or slow moving water, stream traverse, etc.). Present a rationale for choosing each sampling location or sampling area. If decisions will be made in the field, provide details concerning the criteria that will be used to make these decisions (i.e., the decision tree to be followed). List the analytes of concern at each location and provide a rationale for why the specific chemical or group of chemicals (e.g., trace metals) were chosen. For microbiological samples, discuss the types of bacterial samples being collected. Include sampling locations in Figure 2.2 or equivalent.]

4.4 BIOLOGICAL SAMPLING

[For each of the two types of events identified, provide a general overview of the biological sampling event. Present a rationale for choosing each sampling location at the site or sampling area, including the parameters of interest at each location. If decisions will be made in the field, provide details concerning the criteria that will be used to make these decisions (i.e., the decision tree to be followed).

4.4.1.Biological Samples for Chemical Analysis

[For sampling where flora or fauna will be analyzed for the presence of a chemical (e.g. fish collected for tissue analysis), explain why the specific chemical or group of chemicals (e.g., metals, organochlorine pesticides, etc.) is included. List the types of samples to be collected (e.g., fish, by species or size, etc.) and explain how these will be representative. Include sampling locations in Figure 2.2 or equivalent.]

4.4.2.Biological Sample for Species Identification and Habitat Assessment

[If the purpose of the sampling is to collect insects or other invertebrates or to make a habitat assessment, a rationale for the sampling to take place should be provided. For example: what species are of interest and why?]

5 REQUEST FOR ANALYSES

This section should discuss analytical support for the project depending on several factors including the analyses requested, analytes of concern, turnaround times, available resources, available laboratories, etc. If samples will be sent to more than one organization it should be clear which samples go to which laboratory. Field analyses for pH, conductivity, turbidity, or other field tests should be discussed in the sampling section. Field measurements in a mobile laboratory should be discussed here and differentiated from samples to be sent to a fixed laboratory. Field screening tests (for example, immunoassay tests) should be discussed in the sampling section, but the confirmation tests should be discussed here and the totals included in the tables.

[Complete the following narrative subsection concerning the analyses for each matrix. In addition, fill in Tables 5-1 through 5-5, as appropriate. Each table must be completed to list analytical parameters for each type of sample. Include information on container types, sample volumes, preservatives, special handling and analytical holding times for each parameter. Quality Control (QC) samples

(blanks, duplicates, splits, and laboratory QC samples, see Section 10 for description) should be indicated in the column titled "Special Designation." The extra volume needed for laboratory QC samples (for water samples only) should be noted on the table. The tables provided do not have to be used, but the critical information concerning the number of samples, matrix, analyses requested and QC sample identification should be provided in some form. The selected analyses must be consistent with earlier discussion concerning DQOs and analytes of concern. DQI information for the methods should be discussed in Section 8 on quality control requirements.]

5.1 ANALYSES NARRATIVE

[Fill in the blanks. Provide information for each analysis requested. Delete the information below as appropriate. Include any special requests, such as fast turn-around time (2 weeks or less), specific QC requirements, or modified sample preparation techniques in this section.]

5.2 ANALYTICAL LABORATORY

[A QA Plan from the laboratory or SOPs for the methods to be performed must accompanythe SAP.]

6 FIELD METHODS AND PROCEDURES

In the general introductory paragraph to this section, there should be a description of the methods and procedures that will be used to accomplish the sampling goals, e.g., "...collect soil, sediment and water samples." It should be noted that personnel involved in sampling must wear clean, disposable gloves of the appropriate type. The sampling discussion should track the samples identified in Section 4.0 and Table(s) 5-1, 5-2, 5-3, or 5-4. A general statement should be made that refers to the sections containing information about sample tracking and shipping (Section 7). Provide a description of sampling procedures. Example procedures are provided below, but the organization's own procedures can be used instead. In that case, attach a copy of the applicable SOP.

6.1 FIELD EQUIPMENT

6.1.1.List of Equipment Needed

[List all the equipment that will be used in the field to collect samples, including decontamination equipment, if required. Discuss the availability of back-up equipment and spare parts.]

6.1.2.Calibration of Field Equipment

[Describe the procedures by which field equipment is prepared for sampling, including calibration standards used, frequency of calibration and maintenance routines. Indicate where the equipment maintenance and calibration record(s) for the project will be kept.]

6.2 FIELD SCREENING

In some projects a combination of field screening using a less accurate or sensitive method may be used in conjunction with confirmation samples analyzed in a fixed laboratory. This section should describe these methods or reference attached SOPs. Analyses such as soil gas or immunoassay kits are two examples.

[Describe any field screening methods to be used on the project here including how samples will be collected, prepared, and analyzed in the field. Include in an appendix, as appropriate, SOPs covering these methods. Confirmation of screening results should also be described. The role of the field

screening in decision making for the site should also be discussed here if it has not been covered previously.]

6.3 SOIL

6.3.1.Surface Soil Sampling

[Use this subsection to describe the collection of surface soil samples that are to be collected within 15-30 centimeters of the ground surface. Specify the method (e.g., hand trowels) that will be used to collect the samples and use the language below or reference the appropriate sections of a Soil Sampling SOP.]

[If exact soil sampling locations will be determined in the field, this should be stated. The criteria that will be used to determine sampling locations, such as accessibility, visible signs of potential contamination (e.g., stained soils, location of former fuel storage tank, etc.), and topographical features which may indicate the location of hazardous substance disposal (e.g., depressions that may indicate a historic excavation) should be provided.]

Exact soil sampling locations will be determined in the field based on accessibility, visible signs of potential contamination (e.g., stained soils), and topographical features which may indicate location of hazardous substance disposal (e.g., depressions that may indicate a historic excavation). Soil sample locations will be recorded in the field logbook as sampling is completed. A sketch of the sample location will be entered into the logbook and any physical reference points will be labeled. If possible, distances to the reference points will be given.

[If surface soil samples are to be analyzed for organic (non volatile compounds and other analytes, use this paragraph; otherwise delete.]

Surface soil samples will be collected as grab samples (independent, discrete samples) from a depth of 0 to ___centimeters below ground surface (bgs). Surface soil samples will be collected using a stainless steel hand trowel. Samples to be analyzed for volatile organic compounds will be collected first (see below). Samples to be analyzed for __________ [List all analytical methods for soil samples except for volatile organic compounds] will be placed in a sample-dedicated disposable pail and homogenized with a trowel. Material in the pail will be transferred with a trowel from the pail to the appropriate sample containers. Sample containers will be filled to the top, taking care to prevent soil from remaining in the lid threads prior to being closed to prevent potential contaminant migration to or from the sample. Sample containers will be closed as soon as they are filled, chilled to 4°C if appropriate, and processed for shipment to the laboratory.

[If surface soil samples are to be analyzed for volatile organic compounds (VOCs), use this paragraph; otherwise delete.]

Surface soil samples for VOC analyses will be collected as grab samples (independent, discrete samples) from a depth of 0 to ___[centimeters or meters] below ground surface (bgs). Surface soil samples will be collected using a 5 gram Encore sampling device, and will be collected in triplicate. Samples will be sealed using the Encore sampler and a zip lock bag or else transferred directly from the sampler into a VOA vial containing either 10 mLs of methanol or sodium bisulfate solution. Sample containers will be closed as soon as they are filled, chilled immediately to 4°C before wrapping them in bubble wrap, and processed them for shipment to the laboratory.

[For surface soil samples which are not to be analyzed for volatile compounds, use this paragraph; otherwise delete.]

Surface soil samples will be collected as grab samples (independent, discrete samples) from a depth of 0 to ___[centimeters or meters] below ground surface (bgs). Surface soil samples will be collected using a stainless steel hand trowel. Samples will be placed in a sample-dedicated disposable pail and homogenized with a trowel. Material in the pail will be transferred with a trowel from the pail to the appropriate sample containers. Sample containers will be filled to the top, taking care to prevent soil from remaining in the lid threads prior to being closed to prevent potential contaminant migration to or from the sample. Sample containers will be closed as soon as they are filled, chilled if appropriate, and processed for shipment to the laboratory.

6.3.2.Subsurface Soil Sampling

[Use this subsection for subsurface soil samples that are to be collected 30 cm or more below the surface. Specify the method (e.g., hand augers) that will be used to access the appropriate depth and then state the depth at which samples will be collected and the method to be used to collect and then transfer samples to the appropriate containers or reference the appropriate sections of a Soil Sampling SOP. If SOPs are referenced, they should be included in an Appendix.]

[If exact soil sampling locations will be determined in the field, this should be stated. The criteria that will be used to determine sampling locations, such as accessibility, visible signs of potential contamination (e.g., stained soils), and topographical features which may indicate the location of hazardous substance disposal (e.g., depressions that may indicate a historic excavation) should be provided. There should also be a discussion concerning possible problems, such as subsurface refusal]

[Include this paragraph first if exact sampling locations are to be determined in the field; otherwise delete.]

Exact soil sampling locations will be determined in the field based on accessibility, visible signs of potential contamination (e.g., stained soils), and topographical features which may indicate location of hazardous substance disposal (e.g., depressions that may indicate a historic excavation). Soil sample locations will be recorded in the field logbook as sampling is completed. A sketch of the sample location will be entered into the logbook and any physical reference points will be labeled. If possible, distances to the reference points will be given.

[If subsurface soil samples are to be analyzed for volatile compounds, use this paragraph; otherwise delete.]

Samples to be analyzed for volatile organic compounds will be collected first. Subsurface samples will be collected by boring to the desired sample depth using ________________________ __________________ [whatever method is appropriate or available]. Once the desired sample depth is reached, soil samples for VOC analyses will be collected as independent, discrete samples. Surface soil samples will be collected using a 5 gram Encore sampling device, and will be collected in triplicate. Samples will be sealed using the Encore sampler and a zip lock bag or else transferred directly from the sampler into a VOA vial containing either 10 mLs of methanol or sodium bisulfate solution. Sample containers will be closed as soon as they are filled, chilled immediately to 4°C before wrapping them in

bubble wrap, and processed for shipment to the laboratory. [If subsurface soil samples are being collected for other than
volatile organic compounds, use these paragraphs; otherwise delete.]

Subsurface samples will be collected by boring to the desired sample depth using ________________ ______________________________ [whatever method is appropriate or available]. Once the desired sample depth is reached, the ______________________________ [hand- or power-operated device, such as a shovel, hand auger, trier, hollow-stem auger or split-spoon sampler] will be inserted into the hole and used to collect the sample. Samples will be transferred from the _____________________ [sampling device] to a sample-dedicated disposable pail and homogenized with a trowel.

Material in the pail will be transferred with a trowel from the pail to the appropriate sample containers. Sample containers will be filled to the top taking care to prevent soil from remaining in the lid threads prior to being sealed to prevent potential contaminant migration to or from the sample. After sample containers are filled, they will be immediately sealed, chilled if appropriate, and processed for shipment to the laboratory. [Include this as the final paragraph regardless of the analyses for subsurface soil samples.] Excess set-aside soil from the above the sampled interval will
then be repacked into the hole.

6.4 SEDIMENT SAMPLING

[Use this subsection if sediment samples are to be collected. Specify the method (e.g., dredges) that will be used to collect the samples and at what depth samples will be collected. Describe how samples will be homogenized and the method to be used to transfer samples to the appropriate containers. If a SOPwill be followed rather than the language provided, the SOP should be referenced and included in the appendix]

[If exact sediment sampling locations will be determined in the field, this should be stated. Describe where sediment samples will be collected, e.g., slow moving portions of streams, lake bottoms, washes, etc.]

Exact sediment sampling locations will be determined in the field, based on ___________________ ____________________________________ [Describe the criteria to be used to determine sampling locations]. Care will be taken to obtain as representative a sample as possible. The sample will be taken from areas likely to collect sediment deposits, such as slow moving portions of streams or from thebottom of the lake at a minimum depth of .6 meters. Sediment samples will be collected from the well bottom at a depth of _______ inches using a pre-cleaned __________ sampler.

[The final paragraph describes sample homogenization, especially important if the sample is to be separated into solid and liquid phases, and container filling. Include this paragraph, or a modified form of it, for all sediment sampling. It is assumed that sediment samples will not be analyzed for volatilecompounds. If sediment is to be analyzed for volatile organic compounds, the samples to be analyzed for volatile compounds should not be homogenized, but rather transferred directly from the sampler into the sample container. If feasible, an Encore sampling device should be used.]

Material in the sampler will be transferred to a sample-dedicated disposable pail and homogenized with a trowel. Material from the pail will be transferred with a trowel from the bucket to the appropriate sample containers. Sample containers will be filled to the top taking care to prevent soil from remaining in the lid groves prior to being sealed in order to prevent potential contamination migration to or from the sample containers. After sample containers are filled, they will be immediately sealed, chilled if appropriate, and processed for shipment to the laboratory.

6.5 WATER SAMPLING

6.5.1.Surface Water Sampling

[Use this subsection if samples are to be collected in rivers, streams, lakes and reservoirs, or from standing water in runoff collection ponds, gullies, drainage ditches, etc. Describe thesampling procedure, including the type of sample (grab or composite - see definitions below), sample bottle preparation, and project-specific directions for taking the sample. State whether samples will be collected for chemical and/or microbiological analyses. Alternatively, reference theappropriate sections of attached SOPs.]

Grab: Samples will be collected at one time from one location. The sample should be taken from flowing, not stagnant water, and the sampler should be facing upstream in the middle of the stream. Samples will be collected by hand or with a sample bottle holder. For samples taken at a single depth, the bottle should be uncapped and the cap protected from contamination. The bottle should be plunged into the water mouth down and filled 15 to 30 centimeters below the surface of the water. If it is important to take samples at depths, special samplers (e.g., Niskin or Kemmerer Depth Samplers) may be required. After filling the bottle(s), pour out some sample leaving a headspace of 2.5-5cm. For microbiological samples, bottles and caps must be sterile. If sampling of chlorinated water is anticipated, sodium thiosulfate at a concentration of 0.1 mL of a 10% solution for each 125 mL (4 oz) of sample volume must be put into the bottle before it is sterilized. Time Composite: Samples are collected over a period of time, usually 24 hours. If a composite sample is required, a flow- and time-proportional automatic sampler should be positioned to take samples at the appropriate location in a manner such that the sample can be held at 4oC for the duration of the sampling.
Spatial Composite: Samples are collected from different representative positions in the water body and combined in equal amounts. A Churn Splitter or equivalent device will be used to ensure that the sample is homogeneously mixed before the sample bottles are filled. Volatile organic compound samples will be
collected as discrete samples and not composited. [If exact surface water sample locations will be determined in the field, this should be stated. Describe the criteria that will be used to determine where surface water samples will be collected.]

6.5.2.Groundwater Sampling

[This subsection contains procedures for water level measurements, well purging, and well sampling. Relevant procedures should be described under this heading with any necessary site-specific modifications. Alternatively, reference appropriate SOP(s).]

6.5.2.1. Water-Level Measurements

[The following language may be used as is or modified to meet project needs.]

All field meters will be calibrated according to manufacturer's guidelines and specifications before and after every day of field use. Field meter probes will be decontaminated before and after use at each well. If well heads are accessible, all wells will be sounded for depth to water from top of casing and total well depth prior to purging. An electronic sounder, accurate to the nearest +/- cm , will be used to measure depth to water in each well. When using an electronic sounder, the probe is lowered down the casing to the top of the water column, the graduated markings on the probe wire or tape are used to measure the depth to water from the surveyed point on the rim of the well casing. Typically, the measuring device emits a constant tone when the probe is submerged in standing water and most electronic water level sounders have a visual indicator consisting of a small light bulb or diode that turns on when the probe encounters water. Total well depth will be sounded from the surveyed top of casing by lowering the weighted probe to the bottom of the well. The weighted probe will sink into silt, if present, at the bottom of the well screen. Total well depths will be measured by lowering the weighted probe to the bottom of the well and recording the depth to the nearest centimeter. Water-level sounding equipment will be decontaminated before and after use in each well. Water levels will be measured in wells which have the least amount of known contamination first. Wells with known or suspected contamination will be measured last.

6.5.2.2. Purging

[Describe the method that will be used for well purging (e.g., dedicated well pump, bailer, hand pump). Reference the appropriate sections in the Ground Water SOP and state in which Appendix the SOP is located.]

[VERSION A]
All wells will be purged prior to sampling. If the well casing volume is known, a minimum of three casing volumes of water will be purged using the dedicated well pump.

[VERSION B]
All wells will be purged prior to sampling. If the well casing volume is known, a minimum of three casing volumes of water will be purged using a hand pump, submersible pump, or bailer, depending on the diameter and configuration of the well. When a submersible pump is used for purging, clean flexible Teflon tubes will be used for groundwater extraction. All tubes will be decontaminated before use in each well. Pumps will be placed 0.66 to 1 meter from the bottom of the well to permit reasonable drawdown while preventing cascading conditions.

[VERSION C]
All wells will be purged prior to sampling. If the well casing volume is known, a minimum of three casing volumes of water will be purged using the dedicated well pump, if present, or a bailer, hand pump, or submersible pump depending on the diameter and configuration of the well. When a submersible pump is used for purging, clean flexible Teflon tubes will be used for groundwater extraction. All tubes will be decontaminated before use in each well. Pumps will be placed 0.66 to 1 meter from the bottom of thewell to permit reasonable draw down while preventing cascading conditions.

[ALL VERSIONS - to be included in all sample plans]
Water will be collected into a measured bucket to record the purge volume. Casing volumes will be calculated based on total well depth, standing water level, and casing diameter.

It is most important to obtain a representative sample from the well. Stable water quality parameter (temperature, pH and specific conductance) measurements indicate representativesampling is obtainable. Water quality is considered stable if for three consecutive readings:

- Temperature range is no more than +1/C;
- pH varies by no more than 0.2 pH units;
- Specific conductance readings are within 10% of the average.

The water in which measurements were taken will not be used to fill sample bottles. If the well casing volume is known, measurements will be taken before the start of purging, in the middle of purging, and at the end of purging each casing volume. If the well casing volume is NOT known, measurements will be taken every 2.5 minutes after flow starts. If water quality parameters are not stable after 5 casing volumes or 30 minutes, purging will cease, which will be noted in the logbook, and ground water samples will be taken. The depth to water, water quality measurements and purge volumes will be entered in the logbook. If a well dewaters during purging and three casing volumes are not purged, that well will be allowed to recharge up to 80% of the static water column and dewatered once more. After water levels have recharged to 80% of the static water column, groundwater samples will be collected.

6.5.2.3. Well Sampling

[Describe the method that will be used to collect samples from wells. (This will probably be the same method as was used to purge the wells.) Specify the sequence for sample collection (e.g., bottles for volatile analysis will be filled first, followed by semivolatiles, etc.). State whether samples for metals analysis will be filtered or unfiltered. Include the specific conditions, such as turbidity, that will require samples to be filtered. Alternatively, reference the appropriate sections in the Ground Water SOP and state in which Appendix the SOP is located.]

ALL VERSIONS - to be included in all sample plans]

At each sampling location, all bottles designated for a particular analysis (e.g., trace metals) will be filled sequentially before bottles designated for the next analysis are filled. If a duplicate sample is to be collected at this location, all bottles designated for a particular analysis for both sample designations will be filled sequentially before bottles for another analysis are filled. Groundwater samples will be transferred from the tap directly into the appropriate sample containers with preservative, if required, chilled if appropriate, and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the tap to the sample container. [If samples are to be collected for volatiles analysis, the following paragraph should be added; otherwise delete.]

Samples for volatile organic compound analyses will be collected using a low flow sampling device. A [specify type of pump] pump will be used at a flow rate of ______. Vials for volatile organic compound analysis will be filled first to minimize the effect of aeration on the water sample. A test vial will befilled with sample, preserved with hydrochloric acid (HCl) and tested with pH paper to determine the amount of preservative needed to lower the pH to less than 2. The appropriate amount of HCl will then be added to the sample vials prior to the addition of the sample. The vials will be filled directly from the tap and capped. The vial will be inverted and checked for air bubbles to ensure zero headspace. If a bubble appears, the vial will be discarded and a new sample will be collected. [If some samples for metals (or other) analysis are to be filtered, depending upon sample turbidity, the following paragraph should be added; otherwise delete.]

After well purging and prior to collecting groundwater samples for metals analyses, the turbidity of the groundwater extracted from each well will be measured using a portable turbidity meter. A small quantity of groundwater will be collected from the well using the tap and a small amount of water will be transferred to a disposable vial and a turbidity measurement will be taken. The results of the turbidity measurement will be recorded in the field logbook. The water used to measure turbidity will bediscarded after use. If the turbidity of the groundwater from a well is above 5 Nephelometric Turbidity Units (NTUs), both a filtered and unfiltered sample will be collected. A [specify size]-micron filter will be used to remove larger particles that have been entrained in the water sample. A sample-dedicated Teflon tube will be attached to the tap closest to the well head. The filter will be attached to the outlet of the Teflon tube. A clean, unused filter will be used for each filtered sample collected. Groundwater samples will be transferred from the filter directly into the appropriate sample containers with a preservative and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the filter to the sample container. After the filtered sample has been collected, the Teflon tube and filter will be removed and an unfiltered sample will be collected. A sample number appended with an "Fl" will represent a sample filtered with a 5-micron filter.

[If samples are to be filtered for metals (or other) analysis regardless of sample turbidity, the following paragraph should be added; otherwise delete.]

Samples designated for metals analysis will be filtered. A 5-micron filter will be used to remove larger particles that have been entrained in the water sample. A sample-dedicated Teflon tube will be attached to the tap closest to the well head. The filter will be attached to the outlet of the Teflon tube. Aclean, unused filter will be used for each filtered sample collected. Groundwater samples will be transferred from the filter directly into the appropriate sample containers to which preservative has been added and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the filter to the sample container. After the filtered sample has been collected, the Teflon tube and filter will be removed and an unfiltered sample will be collected. A sample number appended with an "Fl" will represent a sample filtered with a 5-micron filter.

6.6 BIOLOGICAL SAMPLING

For the purpose of this guidance, biological sampling falls into two categories. Other types of biological sampling events should be discussed with the QA Office to determine what type of planning document is needed. The two types addressed in this guidance are biological samples being collected for chemical analysis and biological samples for the purpose of assessing species diversity. If the latter type of sampling is planned, a quality assurance project plan may be a more appropriate document. Samples collected for microbiological analyses should be discussed under water sampling.

6.6.1.Biological Sampling for Chemical Analysis

[The two most common types of biological samples being collected for chemical analysis are fish and foliage samples. The following paragraphs are suggested, but field circumstances may dictate alternative collection procedures; if no biological samples will be collected, put "not applicable" by these sections. If a SOP will be followed, include it in the appendix.]

6.6.1.1. Fish Samples

[Use if collecting fish, otherwise delete. Alternatively, reference appropriate SOPs.] Fish will be collected using ______________________ [name method; nets, electroshocking, lines, etc.]. Three fish of each type or species ______________________ [indicate type of fish, e. g., trout, catfish, etc.] will be collected. Efforts will be made to collect fish of approximately the same size and maturity by checking to make sure that lengths and weights do not differ by more than 20%. Once collected the ____________________________ [indicate whether whole fish or filets] will be frozen, wrappedin aluminum foil and plastic bags and sent to a laboratory.

[If samples are to be composited by the laboratory, also indicate that in this section.]

6.6.1.2. Foliage Samples

[Use if collecting foliage samples, otherwise delete. This section may require considerable modification because of the potential diversity of projects involving plants sampling.]

A representative foliage sample will be collected from the target area. It is recommended that a statistical approach be used, if possible. The following plants will be collected: ___________, ___________, and _____________. These plants are being collected because they are were most likely affected by chemicals used in the area. Only foliage showing visible signs of stress or damage will be collected. Stems and twigs will be discarded; leaves only will be collected. The same type of leaf material [Describe material, mature leaves, young shoots, etc.] will be obtained from each plant type. Provided contamination is uniform, material will be composited from several plants to yield a total of about [specify quantity] pound(s) of material. Control samples will also be collected from a nearby unaffected area [Describe area], if available. Latex gloves will be worn during the collection of all samples. Samples will be stored in [describe container, plastic bags, bottles, etc.] and brought to the laboratory as soon as possible to prevent sample deterioration.

6.6.2. Biological Sampling for Species Assessment

[Describe the collection of insects, other invertebrates, or other types of biological samples here. Reference or attach appropriate protocols to support the sampling effort]

6.7 DECONTAMINATION PROCEDURES

[Specify the decontamination procedures that will be followed if non-dedicated sampling equipment is used. Alternatively, reference the appropriate sections in the organization's Decontamination Standard Operating Procedure.]

The decontamination procedures that will be followed are in accordance with approved procedures. Decontamination of sampling equipment must be conducted consistently as to assure the quality of samples collected. All equipment that comes into contact with potentially contaminated soil or water will be decontaminated. Disposable equipment intended for one-time use will not be decontaminated, but will be packaged for appropriate disposal. Decontamination will occur prior to and after each use of a piece of equipment. All sampling devices used, including trowels and augers, will be steam-cleaned or decontaminated according to the following decontamination procedures:

[Use the following decontamination procedures, if samples are collected for organic analyses only; otherwise delete.]

- Non-phosphate detergent and tap water wash, using a brush if necessary.
- Tap-water rinse.
- Deionized/distilled water rinse.
- Pesticide-grade solvent (reagent grade hexane) rinse in a decontamination bucket.
- Deionized/distilled water rinse (twice)

[Use the following decontamination procedures if samples are collected for inorganic (metals) analyses only, otherwise delete.]

- Non-phosphate detergent and tap water wash, using a brush if necessary.
- Tap-water rinse.
- 0.1 N nitric acid rinse.
- Deionized/distilled water rinse (twice).

[Use the following decontamination procedures if samples are collected for both organic and inorganic analyses, otherwise delete.]

- Non-phosphate detergent and tap water wash, using a brush if necessary.
- Tap-water rinse.
- 0.1 N nitric acid rinse.
- Deionized/distilled water rinse.
- Pesticide-grade solvent (reagent grade hexane) rinse in a decontamination bucket.
- Deionized/distilled water rinse (twice).

Equipment will be decontaminated in a predesignated area on pallets or plastic sheeting, and clean bulky equipment will be stored on plastic sheeting in uncontaminated areas. Cleaned small equipment will be stored in plastic bags. Materials to be stored more than a few hours will also be covered.

[NOTE: A different decontamination procedure may be used; but if so, a rationale for using the different approach should be provided.]

7 SAMPLE CONTAINERS, PRESERVATION AND STORAGE

[This section requires a reference to the types of bottles to be used, preparation and preservatives to be added. The organization responsible for adding preservatives should be named. If the information is provided in the request for analyses tables, reference them in the appropriate section below.]

The number of sample containers, volumes, and materials are listed in Section 5.0. The containers are pre-cleaned and will not be rinsed prior to sample collection. Preservatives, if required, will be added by _______ [name of agency/organization doing the sampling] to the containers prior to shipment of the samples to the laboratory.

7.1 SOIL SAMPLES

[If soil samples are to be collected, specify the analyses that will be performed. Use the language below or reference the appropriate sections in the Preservation SOP and state in which Appendix the SOP is located.]

[Include this subsection if collecting soil samples; otherwise delete.]

[If requested analyses include analyses other than volatile organic compounds or metals, include this paragraph; otherwise delete.]

Soil samples for ______________[Include all requested analysis(es), e.g., Pesticides, Semivolatile Organic Compounds] will be homogenized and transferred from the sample-dedicated homogenization pail into 8-ounce (oz), wide-mouth glass jars using a trowel. For each sample, one 8-oz wide-mouth glass jar will be collected for each laboratory. Alternatively, sample will be retained in the brass sleeve in which collected until sample preparation begins. The samples will be chilled to 4/C immediately upon collection.

[If requested analyses include volatile organic compounds, include this paragraph; otherwise delete.]

VOLATILE ORGANIC COMPOUNDS. Soil samples to be analyzed for volatile organic compounds will be stored in their sealed Encore samplers for no more than two days prior to analysis. Frozen Encore sampler samples will be stored for no more than 4 days prior to analysis. If samples are preserved by ejecting into either methanol or sodium bisulfate solution the holding time is two weeks. Preserved samples will be chilled to 4/C immediately upon collection.

[If requested analyses include metals, include this paragraph; otherwise delete.]

METALS. Surface soil samples to be analyzed for metals will be homogenized and transferred from the sample-dedicated homogenization pail into 8-oz, wide-mouth glass jars. For each sample, one 8-oz glass jar will be collected for each laboratory. Samples will not be chilled. Subsurface samples will be retained in their original brass sleeves or other container unless transferred to bottles.

7.2 SEDIMENT SAMPLES

[If sediment samples are to be collected, specify the analyses that will be performed. Use the language below or reference the appropriate sections in a Preservation SOP and state in which Appendix the SOP is located.]

[If requested analyses include analyses other than volatile organic compounds or metals, include this paragraph; otherwise delete.]

______________[Include all requested analysis(es), e.g., Pesticides, Semivolatile Organic Compounds]. Sediment samples will be homogenized and transferred from the sample-dedicated homogenization pail into 8-oz wide-mouth glass jars. For each sample, one 8-oz glass jar will be collected for each laboratory.

The samples will be chilled to 4/C immediately upon collection.

[If requested analyses include volatile organic compounds, include this paragraph; otherwise delete.]

VOLATILE ORGANIC COMPOUNDS. Sediment samples to be analyzed for volatile organic compounds will be stored in their sealed Encore samplers for no more than two days prior to analysis. Frozen Encore sampler samples will be stored for no more than 4 days prior to analysis. If samples are preserved by ejecting into either methanol or sodium bisulfate solution the holding time is two weeks. Preserved samples will be chilled to 4/C immediately upon collection.

[If requested analyses include metals, include this paragraph; otherwise delete.]

METALS. Sediment samples, with rocks and debris removed, which are to be analyzed for metals will be homogenized and transferred from the sample-dedicated homogenization pail into 8-oz, wide-mouth glass jars. For each sample, one 8-oz glass jar will be collected for each laboratory. Samples will not be chilled.

7.3 WATER SAMPLES

[If water samples are to be collected, specify the analyses that will be performed. Use the language below or else reference the appropriate sections in a Preservation SOP and state in which Appendix the SOP is located.]

[Include this subsection if collecting water samples; otherwise delete.]

Depending on the type of analysis (organic or inorganic) requested, and any other project-specific analytical requirements, sample bottles should be plastic (inorganics) or glass (organics), pre-cleaned (general decontamination procedures) or low-detection level pre-cleaned (extensive decontamination procedures).

[Describe the type of bottles that will be used for the project, including the cleaning procedures that will be followed to prepare the bottles for sampling.]

[If requested analyses do not require preservation, include this paragraph; otherwise delete. A separate paragraph should be included for each bottle type.]

______________[Include all requested analysis(es), e.g., Anions, Pesticides, Semivolatile Organic Compounds]. Low concentration water samples to be analyzed for ______________[Specify analysis(es), e.g., Semivolatile Organic Compounds] will be collected in ____________ [Specify bottle type, e. g., 1-liter(L) amber glass bottles]. No preservative is required for these samples. The samples will be chilled to 4/C immediately upon collection. Two bottles of each water sample are required for each laboratory.

[If requested analyses include volatile organic compounds, include this paragraph; otherwise delete.]

VOLATILE ORGANIC COMPOUNDS. Low concentration water samples to be analyzed for volatile organic compounds will be collected in 40-mL glass vials. 1:1 hydrochloric acid (HCl) will be added to the vial prior to sample collection. During purging, the pH will be measured using a pH meter to test at least one vial at each sample location to ensure sufficient acid is present to result in a pH of less than 2. The tested vial will be discarded. If the pH is greater than 2, additional HCl will be added to the sample vials. Another vial will be pH tested to ensure the pH is less than 2. The tested vial will be discarded. The vials will be filled so that there is no headspace. The samples will be chilled to 4/C immediately upon collection. Three vials of each water sample are required for each laboratory.

[If requested analyses include metals, include this paragraph; otherwise delete.]

METALS. Water samples collected for metals analysis will be collected in 1L polyethylene bottles. The samples will be preserved by adding nitric acid (HNO3) to the sample bottle. The bottle will be capped and lightly shaken to mix in the acid. A small quantity of sample will be poured into the bottle cap wherethe pH will be measured using pH paper. The pH must be <2. The sample in the cap will be discarded, and the pH of the sample will be adjusted further if necessary. The samples will be chilled to 4/C immediately upon collection. One bottle of each water sample is required for each laboratory.

GENERAL CHEMISTRY (WATER QUALITY) PARAMETERS. Water samples collected for water quality analysis [Specify what parameters are included. Examples include (but are not limited to) anions (nitrate-N, nitrite-N, sulfate, phosphate), total phosphorus, ammonia-N, total dissolved solids, total suspended solids, alkalinity (may include carbonate, and/or bicarbonate), hardness, cyanide, MBAS (methylene blue active substances), etc.], will be collected in [Specify size of container] polyethylene bottles. The [Specify analysis] samples will be preserved by adding [Describe preservative appropriate to each sample type] to the sample bottle. The [Specify analysis] samples will not be preserved. If preservative is added, the bottle will be capped and lightly shaken to mix in the preservative. Where the preservative affects the pH, a small quantity of sample will be poured into the bottle cap where the pH will be measured using pH paper. The pH must be within the appropriate range. The sample in the cap will be discarded, and the pH of the sample will be adjusted further if necessary. Samples will be chilled to 4/C immediately upon collection. Samples from each location that require the same preservative will be placed in the same bottle if being analyzed by the same laboratory.

7.4 BIOLOGICAL SAMPLES

[If biological samples are to be collected, specify the analyses that will be performed. Use the language below or reference the appropriate sections in a Preservation SOP and state in which Appendix the SOP is located.]

7.4.1.Fish Samples

Fish (whole or fillets) will be wrapped in aluminum foil, labeled, and placed in individual zip lock bags. The samples will be frozen as quickly as possible and shipped using dry ice to maintain the frozen state.

7.4.2.Foliage Samples

[Describe the containers that will be used for the project. Usually foliage samples are collected in clean zip lock bags, but bottles or other containers can be used. Paper bags are not recommended.]

For foliage samples, samples will be collected in a large zip Lock bag. A self adhesive label will be placed on each bag and the top sealed with a custody seal

7.4.3.Biological Sampling for Species Assessment

[Describe the containers in which macroinvertebrates, insects and other biological samples will be stored. If a fixation liquid will be used, it should be described as well. This section should also discuss any special handling procedures which must be followed to minimize damage to the specimens.]

8 DISPOSAL OF RESIDUAL MATERIALS

[This section should describe the type(s) of investigation- derived wastes (IDW) that will be generated during this sampling event. IDW may not be generated in all sampling events, in which case this section would not apply. Use the language below or reference the appropriate sections in a Disposal of Residual Materials SOP and state in which Appendix the SOP is located. Depending upon site-specific conditions and applicable federal, state, and local regulations, other provisions for IDW disposal may be required. If any analyses of IDW are required, these should be discussed. If IDW are to be placed in drums, labeling for the drums should be discussed in this section.]

In the process of collecting environmental samples at the _________[site or sampling area name] during the site investigation (SI) [or name of other investigation], the ________[name of your organization/agency] sampling team will generate different types of potentially contaminated IDW thatinclude the following:

- Used personal protective equipment (PPE).
- Disposable sampling equipment.
- Decontamination fluids[Include this bullet when sampling soils; otherwise delete.]
- Soil cuttings from soil borings [Include this bullet when sampling groundwater; otherwise delete.]
- Purged groundwater and excess groundwater collected for sample container filling.

[The following bullet is generally appropriate for site or sampling areas with low levels of contamination or for routine monitoring. If higher levels of contamination exist at the site or

sampling area, other disposal methods (such as the drumming of wastes) should be used to dispose of used PPE and disposable sampling equipment.]

- Used PPE and disposable equipment will be double bagged and placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of which can still be reused will be rendered inoperable before disposal in the refuse dumpster. [Include this bullet if sampling for both metals and organics; otherwise delete.]
- Decontamination fluids that will be generated in the sampling event will consist of dilute nitric acid, pesticide-grade solvent, deionized water, residual contaminants, and water with non-phosphate detergent. The volume and concentration of the decontamination fluid will be sufficiently low to allow disposal at the site or sampling area. The water (and water with detergent) will be poured onto the ground or into a storm drain. Pesticide-grade solvents will be allowed to evaporate from the decontamination bucket. The nitric acid will be diluted and/or neutralized with sodium hydroxide and tested with pH paper before pouring onto the ground or into a storm drain. [Include this bullet if sampling for metals but not organics; otherwise delete.]
- Decontamination fluids that will be generated in the sampling event will consist of nitric acid, deionized water, residual contaminants, and water with non-phosphate detergent. The volume and concentration of the decontamination fluid will be sufficiently low to allow disposal at the site or sampling area. The water (and water with detergent) will be poured onto the ground or into a storm drain. The nitric acid will be diluted and/or neutralized with sodium hydroxide and tested with pH paper before pouring onto the ground or into a storm drain. [Include this bullet if sampling for organics but not metals; otherwise delete.]
- Decontamination fluids that will be generated in the sampling event will consist of pesticide-grade solvent, deionized water, residual contaminants, and water with non-phosphate detergent. The volume and concentration of the decontamination fluid will be sufficiently low to allow disposal at the site or sampling area. The water (and water with detergent) will be poured onto the ground or into a storm drain. Pesticide-grade solvents will be allowed to evaporate from the decontamination bucket. [Include this bullet if sampling soils; otherwise delete.]
- Soil cuttings generated during the subsurface sampling will be disposed of in an appropriate manner. [Include this bullet if sampling groundwater; otherwise delete.]
- Purged groundwater will be _______________[depending upon the degree of groundwater contamination, site-specific conditions, and applicable federal, state, and local regulations, disposal methods will vary. Disposal methods can also vary for purge water from different wells sampled during the same sampling event].

9 SAMPLE DOCUMENTATION AND SHIPMENT

9.1 FIELD NOTES

This section should discuss record keeping in the field. This may be through a combination of logbooks, preprinted forms, photographs, or other documentation. Information to be maintained is provided below.

9.1.1.Field Logbooks

[Describe how field logbooks will be used and maintained.]

Use field logbooks to document where, when, how, and from whom any vital project information was obtained. Logbook entries should be complete and accurate enough to permit reconstruction of field activities. Maintain a separate logbook for each sampling event or project. Logbooks should have consecutively numbered pages. All entries should be legible, written in black ink, and signed by the individual making the entries. Use factual, objective language.

At a minimum, the following information will be recorded during the collection of each sample:
[Edit this list as relevant.]

- Sample location and description;
- Site or sampling area sketch showing sample location and measured distances;
- Sampler's name(s);
- Date and time of sample collection;
- Designation of sample as composite or grab;
- Type of sample (soil, sediment or water);
- Type of sampling equipment used;
- Field instrument readings and calibration;
- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, etc.);
- Preliminary sample descriptions (e.g., for soils: clay loam, very wet; for water: clear water with strong ammonia-like odor);
- Sample preservation;
- Lot numbers of the sample containers, sample identification numbers and any explanatory codes, and chain-of-custody form numbers;
- Shipping arrangements (overnight air bill number);
- Name(s) of recipient laboratory(ies).

In addition to the sampling information, the following specific information will also be recorded in the field logbook for each day of sampling: [Edit this list as relevant.]

- Team members and their responsibilities;
- Time of arrival/entry on site and time of site departure;
- Other personnel on site;
- Summary of any meetings or discussions with contractor, or federal agency personnel;
- Deviations from sampling plans, site safety plans, and QAPP procedures;
- Changes in personnel and responsibilities with reasons for the changes;
- Levels of safety protection;
- Calibration readings for any equipment used and equipment model and serial number.

[A checklist of the field notes, following the suggestions above, using only those that are appropriate, should be developed and included in project field notes.]

9.1.2.Photographs

[If photographs will be taken, the following language may be used as is or modified as appropriate.]

Photographs will be taken at the sampling locations and at other areas of interest on site or sampling area. They will serve to verify information entered in the field logbook. For each photograph taken, the following information will be written in the logbook or recorded in a separate field photography log:

- Time, date, location, and weather conditions;

- Description of the subject photographed;
- Name of person taking the photograph.

9.2 LABELING

[The following paragraph provides a generic explanation and description of the use of labels. It may be incorporated as is, if appropriate, or modified to meet any project-specific conditions.]

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. A copy of the sample label is included in Appendix __. The samples will have preassigned, identifiable, and unique numbers. At a minimum, the sample labels will contain the following information: station location, date of collection, analytical parameter(s), and method of preservation. Every sample, including samples collected from a single location but going to separate laboratories, will be assigned a unique sample number.

9.3 SAMPLE CHAIN-OF-CUSTODY FORMS AND CUSTODY SEALS

[The following paragraphs provide a generic explanation and description of the use of chain-of-custody forms and custody seals. They may be incorporated as is, if they are appropriate, or modified to meet any project-specific conditions.]

Organic and inorganic chain-of-custody record/traffic report forms are used to document sample collection and shipment to laboratories for analysis. All sample shipments for analyses will be accompanied by a chain-of-custody record. A copy of the form is found in Appendix. Form(s) will be completed and sent with the samples for each laboratory and each shipment (i.e., each day). If multiple coolers are sent to a single laboratory on a single day, form(s) will be completed and sent with the samples for each cooler.

The chain-of-custody form will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if it is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are shipped, the custody of the samples will be the responsibility of _____[name of agency/ organization conducting sampling]. The sampling team leader or designee will sign the chain-of-custody form in the "relinquished by" box and note date, time, and air bill number. The sample numbers for all reference samples, laboratory QC samples, and duplicates will be documented on this form (see Section 10.0). A photocopy will be made for the _____'s [name of agency/ organization conducting sampling] master files.

A self-adhesive custody seal will be placed across the lid of each sample. A copy of the seal is found in Appendix _. For VOC samples, the seal will be wrapped around the cap. The shipping containers in which samples are stored (usually a sturdy picnic cooler or ice chest) will be sealed with self-adhesive custodyseals any time they are not in someone's possession or view before shipping. All custody seals will be signed and dated.

9.4 PACKAGING AND SHIPMENT

[The following paragraphs provide a generic explanation and description of how to pack and ship samples. They may be incorporated as is, if appropriate, or modified to meet any project-specific conditions.]

All sample containers will be placed in a strong-outside shipping container (a steel-belted cooler). The following outlines the packaging procedures that will be followed for low concentration samples.

1. When ice is used, pack it in zip-locked, double plastic bags. Seal the drain plug of the cooler with fiberglass tape to prevent melting ice from leaking out of the cooler.
2. The bottom of the cooler should be lined with bubble wrap to prevent breakage during shipment.
3. Check screw caps for tightness and, if not full, mark the sample volume level of liquid samples on the outside of the sample bottles with indelible ink.
4. Secure bottle/container tops with clear tape and custody seal all container tops.
5. Affix sample labels onto the containers with clear tape.
6. Wrap all glass sample containers in bubble wrap to prevent breakage.
7. Seal all sample containers in heavy duty plastic zip-lock bags. Write the sample numbers on the outside of the plastic bags with indelible ink.
8. Place samples in a sturdy cooler(s) lined with a large plastic trash bag. Enclose the appropriate COC(s) in a zip-lock plastic bag affixed to the underside of the cooler lid.
9. Fill empty space in the cooler with bubble wrap or Styrofoam peanuts to prevent movement and breakage during shipment.
10. Ice used to cool samples will be double sealed in two zip lock plastic bags and placed on top and around the samples to chill them to the correct temperature.
11. Each ice chest will be securely taped shut with fiberglass strapping tape, and custody seals will be affixed to the front, right and back of each cooler.

Records will be maintained by the [organization]'s sample custodian of the following information:

- Sampling contractor's name *(if not the organization itself)*;
- Name and location of the site or sampling area;
- Case or Regional Analytical Program (RAP) number;
- Total number(s) by estimated concentration and matrix of samples shipped to each laboratory;
- Carrier, air bill number(s), method of shipment (priority next day);
- Shipment date and when it should be received by lab;
- Irregularities or anticipated problems associated with the samples;
- Whether additional samples will be shipped or if this is the last shipment.

10 QUALITY CONTROL

This section should discuss the quality control samples that are being collected to support the sampling activity. This includes field QC samples, confirmation samples, background samples,laboratory QC samples, and split samples. Wherever possible, the locations at which the samples will be collected should be identified and a rationale provided for the choice of location. Frequency of collection should be discussed. All samples, except laboratory QC samples, should be sent to the laboratory blind, wherever possible. Laboratory QC samples should be identified and additional sample (e.g., a double volume) collected for that purpose.

10.1 FIELD QUALITY CONTROL SAMPLES

Field quality control samples are intended to help evaluate conditions resulting from field activities and are intended to accomplish two primary goals, assessment of field contamination and assessment of sampling variability. The former looks for substances introduced in the field due to environmental or sampling equipment and is assessed using blanks of different types. The latter includes variability due to sampling technique and instrument performance as well as variability possibly caused by the *heterogeneity of the matrix being sampled and is assessed using replicate sample collection. The following sections cover field QC.*

10.1.1. Assessment of Field Contamination (Blanks)

Field contamination is usually assessed through the collection of different types of blanks. Equipment blanks are obtained by passing distilled or deionized water, as appropriate, over or through the decontaminated equipment used for sampling. They provide the best overall means of assessing contamination arising from the equipment, ambient conditions, sample containers, transit, and the laboratory. Field blanks are sample containers filled in the field. They help assess contamination from ambient conditions, sample containers, transit, and the laboratory. Trip blanks are prepared by the laboratory and shipped to and from the field. They help assess contamination from shipping and thelaboratory and are for volatile organic compounds only. Equipment blanks should be collected, where appropriate (e.g., where neither disposable or dedicated equipment is used). Field blanks are next in priority, and trip blanks next. Only one type of blank must be collected per event, not all three.

10.1.1.1. Equipment Blanks

In general, equipment (rinsate) blanks should be collected whenreusable, non-disposable sampling equipment (e.g., trowels, hand augers, and non-dedicated groundwater sampling pumps) are beingused for the sampling event. Only one blank sample per matrix per day should be collected. If equipment blanks are collected, field blanks and trip blanks are not required under normal circumstances. Equipment blanks can be collected for soil, sediment, and ground water samples. A minimum of one equipment blank is prepared each day for each matrix when equipment is decontaminated in the field. These blanks are submitted "blind" to the laboratory, packaged like other samples and each with its own unique identification number. Note that for samples which may contain VOCs, water for blanks should be purged prior to use to ensure that it is organic free. HPLC water which is often used for equipment and field blanks, can contain VOCs if it is not purged.

[If equipment blanks are to be collected describe how they are to be collected and the analyses that will be performed. A maximum of one blank sample per matrix per day should be collected, but at a rate to not exceed one blank per 10 samples. The 1:10 ratio overrides the one per day requirement. If equipment rinsate blanks are collected, field blanks and trip blanks are not required under normal circumstances. Use the language below or reference the appropriate sections in a Quality Control SOP and state in which Appendix the SOP is located.]

[Include this subsection if equipment blanks are to be collected, otherwise, delete.]

[Include this paragraph if blanks will be analyzed for both metals and organic compounds; otherwise delete.]

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring High Performance Liquid Chromatography (HPLC) organic-free (fororganics) or deionized water (for inorganics) over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing water through or over the decontaminated sampling devices used that day. The rinsate blanks that are collected will be analyzed for ________ [Include names of target analytes, e.g., metals, total petroleum hydrocarbons, volatile organic compounds, etc.].

[Include this paragraph if blanks will be analyzed only for organic compounds; otherwise delete.]

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring High Performance Liquid Chromatography (HPLC) organic-free water over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing water through or over the decontaminated sampling devices used that day. The rinsate blanks that are collected will be analyzed for _________ [Include names of target analytes, e.g., volatile organic compounds, total petroleum hydrocarbons, etc.] [Include this paragraph if blanks will be analyzed only for metals; otherwise delete.]

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring deionized water over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing deionized water through or over the decontaminated sampling devices used that day. The insate blanks that are collected will be analyzed for metals.

[Always include this paragraph.]The equipment rinsate blanks will be preserved, packaged, and sealed in the manner described for the environmental samples. A separate sample number and station number will be assigned to each sample, and it will be submitted blind to the laboratory.

10.1.1.2. Field Blanks

Field blanks are collected when sampling water or air and equipment decontamination is not necessary or sample collectionequipment is not used (e.g., dedicated pumps). A minimum of onefield blank is prepared each day sampling occurs in the field, but equipment is not decontaminated. These blanks are submitted "blind" to the laboratory, packaged like other samples and eachwith its own unique identification number. Note that for samples which may contain VOCs, water for blanks should be purged prior to use to ensure that it is organic free. HPLC water which is often used for equipment and field blanks, can contain VOCs if it is not purged.

[Include this subsection if field blanks will be collected; otherwise delete. Only one blank sample per matrix per day should be collected. If field blanks are prepared, equipment rinsate blanks and trip blanks are not required under normal circumstances.]

[Include this paragraph if blanks will be analyzed for both metals and organic compounds; otherwise delete.]

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling due to ambient conditions or from sample containers. Field blank samples will be obtained by pouring High Performance Liquid Chromatography (HPLC) organic-free water (for organics) and/or deionized water (for inorganics) into a sampling container at the sampling point. The field blanks that are collected will be analyzed for _________ [Include names of target analytes, e.g., metals, volatile organic compounds, etc.].

[Include this paragraph if blanks will be analyzed only for organic compounds; otherwise delete.]

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling due to ambient conditions or from sample containers. Field blank samples will be obtained by pouring High Performance Liquid Chromatography (HPLC) organic-free water into a sampling container at the sampling point. The field blanks that are collected will be analyzed for _________ [Include names of target analytes, e.g., volatile organic compounds, total petroleum hydrocarbons, etc.].

[Include this paragraph if blanks will be analyzed only for metals; otherwise delete.]
Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling due to contamination from sample containers. Field blank samples will be obtained by pouring deionized water into a sampling container at the sampling point. The field blanks that are collected will be analyzed for metals.

[Always include this paragraph.]

The field blanks will be preserved, packaged, and sealed in the manner described for the environmental samples. A separate sample number and station number will be assigned to each sample, and it will be submitted blind to the laboratory.

10.1.1.3. Trip Blanks

Trip blanks are required only if no other type of blank will be collected for volatile organic compound analysis and when air and/or water samples are being collected. If trip blanks are required, one is submitted to the laboratory for analysis with every shipment of samples for VOC analysis. These blanks are submitted "blind" to the laboratory, packaged like other samples and each with its own unique identification number. Note that for samples which may contain VOCs, water for blanks should be purged prior to use to ensure that it is organic free. Laboratory water which is used for trip blanks, can contain VOCs if it is not purged.

[Include this subsection if trip blanks will be collected; otherwise delete. Only one blank sample per matrix per day should be collected. Trip blanks are only relevant to volatile organic compound (VOC) sampling efforts.]

Trip blanks will be prepared to evaluate if the shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected samples. A minimum of one trip blank will be submitted to the laboratory for analysis with every shipment of samples for VOC analysis. Trip blanks are 40 mL vials that have been filled with HPLC-grade water that has been purged so it is VOC free and shipped with the empty sampling containers to the site or sampling area prior to sampling. The sealed trip blanks are not opened in the field and are shipped to the laboratory in the same cooler with the samples collected for volatile analyses. The trip blanks will be preserved, packaged, and sealed in the manner described for the environmental samples. A separate sample number and station number will be assigned to each trip sample and it will be submitted blind to the laboratory.

10.1.1.4. Temperature Blanks

[Include this paragraph with all plans.] For each cooler that is shipped or transported to an analyticallaboratory a 40 mL VOA vial will be included that is marked “temperature blank.” This blank will be used by the sample custodian to check the temperature of samples upon receipt.

10.1.2. Assessment of Field Variability (Field Duplicate or Co-located Samples)

Duplicate samples are collected simultaneously with a standard sample from the same source under identical conditions into separate sample containers. Field duplicates will consist of a homogenized sample divided in two or else a co-located sample. Each duplicate portion should be assigned its own sample number so that it will be blind to the laboratory. A duplicate sample is treated independently of its counterpart in order to assess laboratory performance through comparison of the results. Atleast 10% of samples collected per event should be field duplicates. At least one duplicate should be collected for each sample matrix, but their collection can be stretched out over more than one day (e.g., if it takes more than one day to reach 10 samples). Every group of analytes for which a standard sample is analyzed will also be tested for in one or more duplicate samples. Duplicate samples should be collected from areas of known or suspected contamination. Since the objective is to assess variability due to sampling technique and possible sample heterogeneity, source variability is a good reason to collect co-located samples, not to avoid their collection.

Duplicate soils samples will be collected at sample locations [Identify soil sample locations from which duplicate or collocated samples will be collected for duplicate analysis will be obtained].

Duplicate samples will be collected from these locations because [Add sentence(s) here explaining a rationale for collecting duplicate samples from these locations; e.g., samples from these locations are suspected to exhibit moderate concentrations of contaminants or previous sampling events have detected moderate levels of contamination at the site or sampling area at these locations.]

[Include this paragraph if collecting soil samples and analyzing for compounds other than volatiles;otherwise delete.]

Soil samples to be analyzed for ____________________[List all analytical methods for this sample event except for volatiles.] will be homogenized with a trowel in a sample-dedicated disposable pail. Homogenized material from the bucket will then be transferred to the appropriate wide-mouth glass jars for both the regular and duplicate samples. All jars designated for a particular analysis (e.g., semivolatile organic compounds) will be filled sequentially before jars designated for anotheranalysis are filled (e.g., metals).

[Include this paragraph if collecting soil samples and analyzing for volatiles; otherwise delete.]

Soil samples for volatile organic compound analyses will not be homogenized. Equivalent Encore samples from a colocated location will be collected identically to the original samples, assigned unique sample numbers and sent blind to the laboratory.

[Include these paragraphs if collecting sediment samples. If volatile organic compound analysis will be performed on sediment samples, modify the above paragraph for soil sample volatile analyses by changing "soil" to "sediment."]

Duplicate sediment samples will be collected at sample locations ________________ [Identify sediment sample locations from which duplicate or colocated samples for duplicate analysis will be obtained]. Duplicate samples will be collected from these locations because _________________[Add sentence(s) here explaining a rationale for collecting duplicate samples from these locations; e.g., samples from these locations are suspected to exhibit moderate concentrations ofcontaminants or previous sampling events have detected moderate levels of contamination at the site or sampling area at these locations.] Sediment samples will be homogenized with a trowel in a sample-dedicated 1-gallon disposable pail. Homogenized material from the bucket will then be transferred to the appropriate wide-mouth glass jars for both the regular and duplicate samples. All jars designated for a particular analysis (e.g., semivolatile organic compounds) will be filled sequentially before jarsdesignated for another analysis are filled (e.g., metals).

[Include this paragraph if collecting water samples.]

Duplicate water samples will be collected for water sample numbers _____________ [water sample numbers which will be split for duplicate analysis]. Duplicate samples will be collected from these locations because **________________[Add sentence(s) here explaining a rationale for collecting duplicate samples from these locations; e.g. samples from these locations are suspected to exhibit moderate concentrations of contaminants or previous sampling events have detected moderate levels of contamination at the site or sampling area at these locations.]** When collecting duplicate water samples, bottles with the two different sample identification numbers will alternate in the filling sequence (e.g., a typical filling sequence might be, VOCs designation GW-2, VOCs designation GW-4 (duplicate of GW-2); metals, designation GW-2, metals, designation GW-4, (duplicate of GW-2) etc.). Note that bottles for one type of analysis will be filled before bottles for the next analysis are filled. Volatiles will always be filled first.

[Always include this paragraph.]

Duplicate samples will be preserved, packaged, and sealed in then same manner as other samples of the same matrix. A separate sample number and station number will be assigned to each duplicate, and it will be submitted blind to the laboratory.

10.2 BACKGROUND SAMPLES

Background samples are collected in situations where the possibility exists that there are native or ambient levels of one or more target analytes present or where one aim of the sampling event is to differentiate between on-site and off-site contributions to contamination. One or more locations are chosen which should be free of contamination from the site or sampling location itself, but have similar geology, hydrogeology, or other characteristics to the proposed sampling locations that mayhave been impacted by site activities. For example, an area adjacent to but removed from the site, upstream from the sampling points, or up gradient or cross gradient from the groundwater under the site. Not all sampling events require background samples.

[Specify the sample locations that have been designated as background. Include a rationale for collecting background samples from these locations and describe or reference the sampling and analytical procedures which will be followed to collect these samples.]

10.3 FIELD SCREENING AND CONFIRMATION SAMPLES

For projects where field screening methods are used (typically defined as testing using field test kits, immunoassay kits, or soil gas measurements or equivalent, but not usually defined as the use of a mobile laboratory which generates data equivalent to a fixed laboratory), two aspects of the tests should be described. First, the QC which will be run in conjunction with the field screening method itself, and, second, any fixed laboratory confirmation tests which will be conducted. QC acceptance criteria for these tests should be defined in these sections rather than in the DQO section.

10.3.1. Field Screening Samples

[For projects where field screening methods are used describe the QC, samples which will be run in the field to ensure that the screening method is working properly. This usually consists of a combination of field duplicates and background (clean) samples). The discussion should specify acceptance criteria and corrective action to be taken if results are not within defined limits. Discuss confirmation tests below.]

10.3.2. Confirmation Samples

If the planned sampling event includes a combination of fieldscreening and fixed laboratory confirmation, this section should describe the frequency with which the confirmation samples willbe collected and the criteria which will be used to select confirmation locations. These will both be dependent on the use of the data in decision making. It is recommended that the selection process be at a minimum of 10% and that a selection criteria include checks for both false positives (i.e., the fielddetections are invalid or the concentrations are not accurate) and false negatives (i.e., the analyte was not detected in the field). Because many field screening techniques are less sensitive than laboratory methods false negative screening is especially important unless the field method is below the actionlevel for any decision making. It is recommended that some "hits" be chosen and that other locations be chosen randomly.

[Describe confirmation sampling. Discuss the frequency with which samples will be confirmed and how location will be chosen. Define acceptance criteria for the confirmation results (e.g., RPD#25%) and corrective actions to be taken if samples are not confirmed.]

10.3.3. Split Samples

Split Samples are defined differently by different organizations, but for the purpose of this guidance, s split samplesare samples that are divided among two or more laboratory for the purpose of providing an inter-laboratory or inter-organization comparison. Usually one organization (for example, a responsible party) collects the samples and provides sufficient material to the other organization (for example, EPA) to enable it to perform independent analyses. It is expected that the sampling party will have prepared a sampling plan which the QA Office has reviewed and approved that describes thesampling locations and a rationale for their choice, sampling methods, and analyses.

[Describe the purpose of the split sampling. Include references to the approved sampling plan of the party collecting the samples. Provide a rationale for the sample locations at which split samples will be obtained and how these locations are representative of the sampling event as a whole. Describe howresults are to be compared and define criteria by which agreement will be measured. Discuss corrective action to be taken if results are found to not be in agreement.]

10.4 LABORATORY QUALITY CONTROL SAMPLES

Laboratory quality control (QC) samples are analyzed as part of standard laboratory practice. The laboratory monitors the precision and accuracy of the results of its analytical procedures through analysis of QC samples. In part, laboratory QC samples consist of matrix spike/matrix spike duplicate samples for organic analyses, and matrix spike and duplicate samples for inorganic analyses. The term "matrix" refers to use of the actual media collected in the field (e.g., routine soil and water samples).

Laboratory QC samples are an aliquot (subset) of the field sample. They are not a separate sample, but a specialdesignation of an existing sample.

[Include the following language if soil samples are to be collected for other than VOCs. Otherwise delete.]

A routinely collected soil sample (a full 8-oz sample jar or two 120-mL sample vials) contains sufficient volume for both routine sample analysis and additional laboratory QC analyses. Therefore, a separate soil sample for laboratory QC purposes will not be collected. [Include the following language if soil samples are to be collected for other than VOCs. Otherwise delete.] Soil samples for volatile organic compound analyses for laboratory QC purposes will be obtained by collecting double the number of equivalent Encore samples from a colocated location in the same way as the original samples, assigned a unique sample numbers and sent blind to the laboratory.

[Include the following language if water samples are to be collected. Otherwise delete.]

For water samples, double volumes of samples are supplied to the laboratory for its use for QC purposes. Two sets of water sample containers are filled and all containers are labeled with a single sample number.

For VOC samples this would result in 6 vials being collected instead of 3, for pesticides and semivolatile samples this would be 4 liters instead of 2, etc.

The laboratory should be alerted as to which sample is to be used for QC analysis by a notation on the sample container label and the chain-of-custody record or packing list. At a minimum, one laboratory QC sample is required per 14 days or one per 20 samples (including blanks and duplicates), whicheveris greater. If the sample event lasts longer than 14 days or involves collection of more than 20 samples per matrix, additional QC samples will be designated.

For this sampling event, samples collected at the following locations will be the designated laboratory QC samples: [If a matrix is not being sampled, delete the reference to that matrix.]

- For soil, samples _____________ [List soil sample locations and numbers designated for QA/QC.]
- For sediment, samples _____________[List sediment sample locations and numbers designated for QA/QC.]
- For water, samples _____________ [List water sample locations and numbers designated for QA/QC.]

[Add a paragraph explaining why these sample locations were chosen for QA/QC samples. QA/QC samples should be samples expected to contain moderate levels of contamination. A rationale should justify the selection of QA/QC samples based on previously-detected contamination at the site or sampling area, historic site or sampling area operations, expected contaminant deposition/migration, etc.]

11 FIELD VARIANCES

[It is not uncommon to find that, on the actual sampling date, conditions are different from expectations such that changes must be made to the SAP once the samplers are in the field. The following paragraph provides a means for documenting those deviations, or variances.Adopt the paragraph as is, or modifyit to project-specific conditions.]

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling as presented in this plan. When appropriate, the QA Office will be notified and a verbal approval will be obtained before implementing the changes. Modifications to the approved plan will be documented in the sampling project report.

12 FIELD HEALTH AND SAFETY PROCEDURES

[Describe any agency-, program- or project-specific health and safety procedures that must be followed in the field, including safety equipment and clothing that may be required, explanation of potential hazards that may be encountered, and location and route to the nearest hospital or medical treatment facility. A copy of the organization health and safety plan may be included in the Appendix and referenced in this section.]

APPENDIX G. INTERNATIONAL CYANIDE CODE

August 2008
www.cyanidecode.org

THE INTERNATIONAL CYANIDE CODE
The following attachment presents the International Cyanide Code was developed by the mining industry. It is a voluntary Code of practice. Once a mining company commits to complying with the Code, it pays funds to the Code management organization and agrees to be audited by an outside engineering firm. That firm visits the mine site and determines if the company is complying with the Code's requirements for the transport, storage, handling, use, treatment and disposal of cyanide. If a mining company is found to be in compliance, the Code organization issues a compliance notification which is placed on the Code web site. Companies complying with the Code also agree to be audited every 3-5 years to assure that the Code is being complied with. It should be noted that many countries have developed regulations of cyanide use at mines which are more stringent that the Code. The Code should be viewed as a minimum program, not a Best Management Practice.

INTERNATIONAL CYANIDE MANAGEMENT INSTITUTE

The International Cyanide Management Code

www.cyanidecode.org

August 2008

The International Cyanide Management Code (hereinafter "the Code") and other documents or information sources referenced at *www.cyanidecode.org* are believed to be reliable and were prepared in good faith from information reasonably available to the drafters. However, no guarantee is made as to the accuracy or completeness of any of these other documents or information sources. No guarantee is made in connection with the application of the Code, the additional documents available or the referenced materials to prevent hazards, accidents, incidents, or injury to employees and/or members of the public at any specific site where gold is extracted from ore by the cyanidation process. Compliance with this Code is not intended to and does not replace, contravene or otherwise alter the requirements of any specific national, state or local governmental statutes, laws, regulations, ordinances, or other requirements regarding the matters included herein. Compliance with this Code is entirely voluntary and is neither intended nor does it create, establish, or recognize any legally enforceable obligations or rights on the part of its signatories, supporters or any other parties.

1 SCOPE

The Code is a voluntary initiative for the gold mining industry and the producers and transporters of the cyanide used in gold mining. It is intended to complement an operation's existing regulatory requirements. Compliance with the rules, regulations and laws of the applicable political jurisdiction is necessary; this Code is not intended to contravene such laws.

The Code focuses exclusively on the safe management of cyanide that is produced, transported and used for the recovery of gold, and on cyanidation mill tailings and leach solutions. The Code originally was developed for gold mining operations, and addresses production, transport, storage, and use of cyanide and the decommissioning of cyanide facilities. It also includes requirements related to financial assurance, accident prevention, emergency response, training, public reporting, stakeholder involvement and verification procedures. Cyanide producers and transporters are subject to the applicable portions of the Code identified in their respective Verification Protocols.

It does not address all safety or environmental activities that may be present at gold mining operations such as the design and construction of tailings impoundments or long-term closure and rehabilitation of mining operations.

The term "cyanide" used throughout the Code generically refers to the cyanide ion, hydrogen cyanide, as well as salts and complexes of cyanide with a variety of metals in solids and solutions. It must be noted that the risks posed by the various forms of cyanide are dependent on the specific species and concentration. Information regarding the different chemical forms of cyanide is found at *http://www.cyanidecode.org/cyanide_chemistry.php*.

2 CODE IMPLEMENTATION

As it applies to gold mining operations, the Code is comprised of two major elements. The Principles broadly state commitments that signatories make to manage cyanide in a responsible manner. Standards of Practice follow each Principle, identifying the performance goals and objectives that must be met to comply with the Principle. The Principles and Practices applicable to cyanide production and transportation operations are included in their respective Verification Protocols. Operations are certified as being in compliance with the Code upon an independent third-party audit verifying that they meet the Standards of Practice, Production Practice or Transport Practice.

For implementation guidance, visit http://www.cyanidecode.org/become_implementation.php

The programs and procedures identified by the Code's Principles and Standards of Practice and in the Cyanide Production and Transportation Verification Protocols for the management of cyanide can be developed separately from other programs, or they can be integrated into a site's overall safety, health and environmental management programs. Since operations typically do not have direct control over all phases of cyanide production, transport or handling, gold mines that are undergoing Verification Audits for certification under the Code will need to require that other entities involved in these activities and that are not themselves Code signatories commit to and demonstrate that they adhere to the Code's Principles and meet its Standards of Practice for these activities.

This Code, the implementation guidance, mine operators guide, and other documents or information sources referenced at *www.cyanidecode.org* are believed to be reliable and were prepared in good faith from information reasonably available to the drafters. However, no guarantee is made as to the accuracy or completeness of any of these other documents or information sources. The implementation guidance, mine operators guide, and the additional documents and references are not intended to be part of the Code. No guarantee is made in connection with the application of the Code, the additional documents available or the referenced materials to prevent hazards, accidents, incidents, or injury to employees and/or members of the public at any specific site where gold is extracted from ore by the cyanidation process. Compliance with this Code is not intended to and does not replace, contravene or otherwise alter the requirements of any specific national, state or local governmental statutes, laws, regulations, ordinances, or other requirements regarding the matters included herein. Compliance with this Code is entirely voluntary and is neither intended nor does it create, establish, or recognize any legally enforceable obligations or rights on the part of its signatories, supporters or any other parties.

3 PRINCIPLES AND STANDARDS OF PRACTICE

3.1 PRODUCTION Encourage responsible cyanide manufacturing by purchasing from manufacturers who operate in a safe and environmentally protective manner.

Standard of Practice

3.1.1 Purchase cyanide from manufacturers employing appropriate practices and procedures to limit exposure of their workforce to cyanide and to prevent releases of cyanide to the environment.

3.2 TRANSPORTATION Protect communities and the environment during cyanide transport.

Standards of Practice

3.2.1 Establish clear lines of responsibility for safety, security, release prevention, training and emergency response in written agreements with producers, distributors and transporters.

3.2.2 Require that cyanide transporters implement appropriate emergency response plans and capabilities, and employ adequate measures for cyanide management.

3.3 HANDLING AND STORAGE Protect workers and the environment during cyanidehandling and storage.

Standards of Practice

3.3.1 Design and construct unloading, storage and mixing facilities consistent with sound, accepted engineering practices and quality control and quality assurance procedures, spill prevention and spill containment measures.

3.3.2 Operate unloading, storage and mixing facilities using inspections, preventive maintenance and contingency plans to prevent or contain releases and control and respond to worker exposures.

3.4 OPERATIONS Manage cyanide process solutions and waste streams to protecthuman health and the environment.

Standards of Practice

3.4.1 Implement management and operating systems designed to protect human health and the environment including contingency planning and inspection and preventive maintenance procedures.
3.4.2 Introduce management and operating systems to minimize cyanide use, thereby limiting concentrations of cyanide in mill tailings.
3.4.3 Implement a comprehensive water management program to protect against unintentional releases.
3.4.4 Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions.
3.4.5 Implement measures to protect fish and wildlife from direct and indirect discharges of cyanide process solutions to surface water.
3.4.6 Implement measures designed to manage seepage from cyanide facilities to protect the beneficial uses of ground water.
3.4.7 Provide spill prevention or containment measures for process tanks and pipelines.
3.4.8 Implement quality control/quality assurance procedures to confirm that cyanide facilities are constructed according to accepted engineering standards and specifications.
3.4.9 Implement monitoring programs to evaluate the effects of cyanide use on wildlife, surface and ground water quality.

3.5 DECOMMISSIONING Protect communities and the environment from cyanide through development and implementation of decommissioningplans for cyanide facilities.

Standards of Practice

3.5.1 Plan and implement procedures for effective decommissioning of cyanide facilities to protect human health, wildlife and livestock.
3.5.2 Establish an assurance mechanism capable of fully funding cyanide-related decommissioning activities.

3.6 WORKER SAFETY Protect workers' health and safety from exposure to cyanide.

Standards of Practice

3.6.1 Identify potential cyanide exposure scenarios and take measures as necessary to eliminate, reduce and control them.
3.6.2 Operate and monitor cyanide facilities to protect worker health and safety and periodically evaluate the effectiveness of health and safety measures.
3.6.3 Develop and implement emergency response plans and procedures to respond to worker exposure to cyanide.

3.7 EMERGENCY RESPONSE Protect communities and the environment through thedevelopment of emergency response strategies andcapabilities.

Standards of Practice

3.7.1 Prepare detailed emergency response plans for potential cyanide releases.
3.7.2 Involve site personnel and stakeholders in the planning process.
3.7.3 Designate appropriate personnel and commit necessary equipment and resources for emergency response.
3.7.4 Develop procedures for internal and external emergency notification and reporting.
3.7.5 Incorporate into response plans monitoring elements and remediation measures that account for the additional hazards of using cyanide treatment chemicals.
3.7.6 Periodically evaluate response procedures and capabilities and revise them as needed.

3.8 TRAINING Train workers and emergency response personnel to manage cyanide in a safe and environmentally protective manner.

Standards of Practice

3.8.1` Train workers to understand the hazards associated with cyanide use.
3.8.2 Train appropriate personnel to operate the facility according to systems and procedures that protect human health, the community and the environment.
3.8.3 Train appropriate workers and personnel to respond to worker exposures and environmental releases of cyanide.

3.9 DIALOGUE Engage in public consultation and disclosure.

Standards of Practice

3.9.1 Provide stakeholders the opportunity to communicate issues of concern.
3.9.2 Initiate dialogue describing cyanide management procedures and responsively address identified concerns.
3.9.3 Make appropriate operational and environmental information regarding cyanide available to stakeholders.

4 CODE MANAGEMENT

4.1 Administration

The International Cyanide Management Institute ("The Institute") is a non-profit corporation established to administer the Code through a multi- stakeholder Board of Directors consisting of representatives of the gold mining industry and participants from other stakeholder groups. For additional information on the Institute, see: http://www.cyanidecode.org/whoicmi.php.

The Institute's primary responsibilities are to:

- Promote adoption of and compliance with the Code, and to monitor its effectiveness and implementation within the world gold mining industry.
- Develop funding sources and support for Institute activities.
- Work with governments, NGOs, financial interests and others to foster widespread adoption and support of the Code.
- Identify technical or administrative problems or deficiencies that may exist with Code implementation, and
- Determine when and how the Code should be revised and updated.

4.2 Code Signatories

Gold mining companies with either single or multiple operations, and the producers and transporters of cyanide used in gold mining can become signatories to the Code; the signature of an owner or corporate officer of the operating company is required. By becoming a signatory, a company commits to follow the Code's Principles and implement its Standards of Practice, or in the case of producers and transporters, the Principles and Practices identified in their respective Verification Protocols. Code signatories' operations will be audited to verify their operation's compliance with the Code.

When becoming a signatory, a gold mining company must specify which of its operations it intends on having certified. Only those cyanide production and transportation facilities that are related to the use of cyanide in gold mining are subject to certification. A company that does not have these operations audited within 3 years of signing the Code will lose its signatory status. See: http://www.cyanidecode.org/signatorycompanies.php.

4.3 Code Verification and Certification

Audits are conducted every three years by independent, third-party professionals who meet the Institute's criteria for auditors. The audit is considered to be complete, and the three-year period before the next audit must be conducted begins, on the day the Institute takes formal certification action based on the auditor's findings. Auditors evaluate an operation to determine if its management of cyanide achieves the Code's Principles and Standards of Practice, or the Production or Transport Practices for these types of operations. The Code's Verification Protocols contains the criteria for all audits. Operations must make all relevant data available to the auditors, including the complete findings of their most recent independent Code Verification Audit, in order to be considered for certification.

During an initial verification audit, an operation's compliance at the time of the audit will be evaluated. Subsequent re-verification audits will also evaluate compliance during the period between the receding and current audits.

Upon completion of the audit, the auditor must review the findings with the operation to ensure that the audit is factually accurate and make any necessary changes. The auditor must submit a detailed "Audit Findings Report" addressing the criteria in the Verification Protocol and a "Summary Audit Report" that includes the conclusion regarding the operation's compliance with the Code to the signatory, the operation and to the Institute. The operation is certified as complying with the Code if the auditor concludes that it is in full compliance with the Code's Principles and Standards of Practice or its Principles and Practices for cyanide production or transportation. The detailed "Audit Findings Report" is the confidential property of the operation and shall not be released by the Institute in any fashion without the express written consent of the signatory and audited operation. The "Summary Audit Report" of certified operations will be made available to the public on the Code website. The operation may submit its comments regarding the Summary Audit Report to the Institute, which will be posted along with the Summary Audit Report on the Institute's website.

Operations that are in substantial compliance with the Code are conditionally certified, subject to the successful implementation of an Action Plan. Substantial compliance means that the operation has made a good-faith effort to comply with the Code and that the deficiencies identified by the auditor can be readily corrected and do not present an immediate or substantial risk to employee or community health or the environment. Operations that are in substantial compliance with a Standard of Practice, Production Practice or Transport Practice must develop and implement an Action Plan to correct the deficiencies identified by the verification audit. The operation may request that the auditor review the Action Plan or assist in its development so that there is agreement that its implementation will bring the operation into full compliance. The Action Plan must include a time period mutually agreed to with the auditor, but in no case longer than one year, to bring the operation into full compliance with the Code. The Auditor must submit the Action Plan to the Institute along with the Audit Findings Report and Summary Audit Report.

The operation must provide evidence to the auditor demonstrating that it has implemented the Action Plan as specified and in the agreed-upon time frame. In some cases, it may be necessary for the auditor to re-evaluate the operation to confirm that the Action Plan has been implemented. Upon receipt of the documentation that the Action Plan has been fully implemented, the auditor must provide a copy of the documentation to the Institute along with a statement verifying that the operation is in full compliance with the Code.

All operations certified as in compliance with the Code will be identified on the Code website, *http://www.cyanidecode.org/signatorycompanies.php*. Each certified operation's Summary Audit Report will be posted and operations with conditional certification will have their Summary Audit Report and their Action Plan posted.

An operation cannot be certified if the auditor concludes that it is neither in full compliance nor in substantial compliance with any one of the Standards of Practice (or Production or Transport Practice). An operation that is not certified based on its initial verification audit can be verified and certified once it has brought its management programs and procedures into compliance with the Code. Its signatory parent company remains a signatory during this process.

A gold mining operation that is not yet active but that is sufficiently advanced in its planning and design phases can request pre-operational conditional certification based on an auditor's review of its site plans and proposed operating procedures. An on-site audit is required within one year of the operation's first receipt of cyanide at the site to confirm that the operation has been constructed and is being operated in compliance with the Code. These operations must advise ICMI within 90 days of the date of their first receipt of cyanide at the operation.

Mining operations that have been designated for certification before they become active but which do not request pre-operational certification must be audited for compliance with the Code within one year of their first receipt of cyanide, and also must advise ICMI within 90 days of the date of their first receipt of cyanide.

A gold mining operation or an individual cyanide facility at an operation is no longer subject to certification after decommissioning of the cyanide facilities. A producer or transporter is no longer subject to certification after it no longer produces or transports cyanide for use in the gold mining industry.

4.4 Certification Maintenance

In order to maintain certification, an operation must meet all of the following conditions:

- The auditor has concluded that it is either in full compliance or substantial compliance with the Code.
- An operation in substantial compliance has submitted an Action Plan to correct its deficiencies and has demonstrated that it has fully implemented the Action Plan in the agreed-upon time.
- There is no verified evidence that the operation is not in compliance with the Code.
- An operation has had a verification audit within three years.
- An operation has had a verification audit within two years of a change in ownership, defined as a change of the controlling interest of the operating company

4.5 Auditor Criteria and Review Process

The Institute has developed specific criteria for Code Verification auditors and will implement procedures for review of auditor credentials. Auditor criteria includes requisite levels of experience with cyanidation operations (or chemical production facilities or hazardous materials transport, as appropriate) and in conducting environmental, health or safety audits, membership in a self-regulating professional auditing association and lack of conflicts of interest with operation(s) to be audited.

4.6 Dispute Resolution

The Institute has developed and implemented fair and equitable procedures for resolution of disputes regarding auditor credentials and certification and/or de-certification of operations. The procedures provide due process to all parties that may be affected by these decisions.

4.7 Information Availability

The Code and related information and code management documentation are available via the Internet at www.cyanidecode.org. The website is intended to promote an understanding of the issues involved in cyanide management and to provide a forum for enhanced communication within and between the various stakeholder groups with interest in these issues. The website is the repository for Code certification and verification information.

5 ACKNOWLEDGEMENTS

This project was underwritten by a group of gold companies and cyanide producers from around the world. The Gold Institute was instrumental in organizing this financial and technical support and provided the administrative and logistical support necessary to successfully complete the project. This effort represents the first time that an industry has worked with other stakeholders to develop an international voluntary industry Code of Practice. The individuals listed below participated in the process. Participation by these individuals does not necessarily represent an endorsement of the Code by their respective organizations.

<u>Steering Committee</u>
Harold Barnes (Chairman)[1] Homestake Mining Company, United States
Stephen Bailey International Finance Corporation, United States
Julio Bonelli Government of Peru
Gordon Drake, Ph.D[2] WMC Resources, Ltd., Australia
John den Dryver[3] Normandy Mining Limited, Australia
Bill Faust Eldorado Gold Company, Canada
Fred Fox[4] Kennecott Minerals Company, United States
John Gammon, Ph.D. Government of Ontario, Canada
Steven Hunt[5] United Steelworkers of America, Canada
Juergen Loroesch, Ph.D. Degussa, Germany
Basie Maree Anglogold Company, South Africa
Glenn Miller, Ph.D. University of Nevada, Reno, United States
Anthony O'Neill WMC Resources, Ltd., Australia
Michael Rae World Wide Fund For Nature, Australia
Stan Szymanski International Council of Chemical Associations, United States
Stephan Theben6 European Commission, Spain
Federico Villasenor5 Minas Luismin, Mexico
Juergen Wettig European Commission, Belgium

1 Elected Chairman by the Steering Committee
2 Substituted for Anthony O'Neill at Washington and Vancouver Meetings
3 Substituted for Anthony O'Neill at Santiago Meeting
4 Replaced Bill Faust on Committee after Napa Meeting
5 Added to Steering Committee at Vancouver Meeting
6 Substituted for Juergen Wettig at Washington, Vancouver and Santiago Meetings

<u>Code Manager</u>
Norman Greenwald Norm Greenwald Associates, United States

<u>Secretariat</u>
Wanda Hoskin United Nations Environment Programme, France
Tom Hynes, Ph.D. International Council on Metals and the Environment, Canada
Kathryn Tayles United Nations Environment Programme, France

<u>Gold Institute</u>
Paul Bateman The Gold Institute, United States

Industry Advisory Group
Anglogold, South Africa Homestake Mining Company, United States
Ashanti Goldfields Company, Ghana Kinross Gold Corp., Canada
Australian Gold Council, Australia Lihir Management Corp., Paupa New Guinea
Australian Gold Reagents, Australia Mining Project Investors, Australia
Barrick Gold Corp., Canada Newmont Gold Company, United States
Degussa, Germany Normandy Mining, Australia
Dupont, United States Placer Dome, Inc., Canada
Glamis Gold, Ltd., United States South African Chamber of Mines, South Africa
Gold Fields Limited, South Africa Rio Tinto, United Kingdom
The Gold Institute, United States WMC, Australia

APPENDIX H. WORLD BANK FINANCIAL SURETY

GUIDANCE NOTES FOR THE
IMPLEMENTATION OF
FINANCIAL SURETY FOR
MINE CLOSURE
SASSOON 2008 WORLD BANK

http://siteresources.worldbank.org/INTOGMC/Resources/financial_surety_mine.pdf

The World Bank Group
Oil, Gas and Mining Policy Division
GUIDANCE NOTES FOR THE
IMPLEMENTATION OF
FINANCIAL SURETY FOR
MINE CLOSURE
SASSOON 2008 WORLD BANK

1 INTRODUCTION

It is now accepted practice that when a company relinquishes a mining title, whether for an exploration or mining site, it is responsible for carrying out the rehabilitation of that site prior to departure. To ensure this is the case, most jurisdictions now require some form of closure plan or rehabilitation program to be submitted to the regulatory authority prior to any work starting on the site. It is an increasingly common requirement for the closure plan to contain details of the estimated cost of rehabilitation and for a financial surety to be established at the same time.

This report aims to provide the information necessary to assist governments in making their own, informed decisions regarding financial surety for mine closure. The report is based on a review of existing financial surety systems in a number of countries. Questionnaires were sent out to a total of 14 regulatory authorities and, of these, nine provided sufficient detail about their existing financial surety systems to be included as full case studies. These are presented in Chapter 3 along with a summary of the latest European Union waste directive. Except where otherwise stated, the financial surety applies to all stages of a mining project whatever the size.

The latest IFC (World Bank) Environmental, Health, and Safety Guidelines for Mining (2007) state that mine closure and post closure should be included in business feasibility at the design stage with the minimum consideration being the availability of funds to cover the cost of closure. These funds should be established by a cash accrual system or financial guarantee. The relevant section of the Guidelines is reproduced in Box 1.1.

The purpose of the financial surety is to ensure that there will be sufficient funds available to pay for site rehabilitation and post closure monitoring and maintenance at any stage in the life of the project including early or temporary closure. The main aims of site rehabilitation are to reduce the risk of pollution, to restore the land and landscape for an appropriate use, to improve the aesthetics of the area and to prevent any subsequent degradation. The extent and cost of final site rehabilitation can be reduced if it is undertaken on a progressive basis wherever possible, as mining takes place, so that the rate of restoration is similar to the rate of exploration or exploitation. This ideal is not often achieved and it is more common for the majority of rehabilitation to take place once work on the lease has ceased.

The cost of mine closure can vary enormously as the following extract from the World Bank and IFC publication (2002) shows:

"Closure costs for environmental issues range from less than US$1 million each for small mines in Romania to hundreds of millions of dollars for large lignite mines and associated facilities in Germany. More typically, closure costs will range in the tens of millions of dollars. Preliminary research indicates that medium-size open pit and underground mines operating in the past 10 to 15 years cost US$5-15 million to close, while closure of open pit mines operating for over 35 years, with large waste and tailings facilities, can cost upwards of $50 million."

This means that the required level of financial surety can differ dramatically between countries and should only be established on a country by country and site by site basis. In addition, because of the variation in conditions, it is not feasible to establish a definitive guide. However, the regulatory authority does need to be consistent in their approach to determining end goals, or rehabilitation standards, and assessing the financial surety requirements. These should include, but not be limited to: the removal of all plant, equipment and, where it is no longer needed, infrastructure; the removal of all hazardous materials; the sealing of adits; the stabilization of all surfaces; the revegetation of all surfaces; the restoration of surface and ground water flows; the prevention of long term pollution.

In some instances the mining community may have become reliant on the cash flow, infrastructure and facilities provided by, or because of, the mine. It is becoming accepted that these social assets and services should be taken into consideration when establishing the financial implications of mine closure and that funds should be set aside for this purpose.

Box 1.1: IFC Guidelines for Mine Closure and Post Closure

Closure and post-closure activities should be considered as early in the planning and design stages as possible. Mine sponsors should prepare a Mine Reclamation and Closure Plan (MRCP) in draft form prior to the start of production, clearly identifying allocated and sustainable funding sources to implement the plan. For short life mines, a fully detailed Mine Reclamation and Closure Plan (with guaranteed funding) as described below should be prepared prior to the start of operations. A mine closure plan that incorporates both physical rehabilitation and socio-economic considerations should be an integral part of the project life cycle and should be designed so that:

- Future public health and safety are not compromised;
- The after-use of the site is beneficial and sustainable to the affected communities in the long term;
- Adverse socio-economic impacts are minimized and socioeconomic benefits are maximized.

The MRCP should address beneficial future land use (this should be determined using a multistake holder process that includes regulatory agencies, local communities, traditional land users, adjacent leaseholders, civil society and other impacted parties), be previously approved by the relevant national authorities, and be the result of consultation and dialogue with local communities and their government representatives.

The closure plan should be regularly updated and refined to reflect changes in mine development and operational planning, as well as the environmental and social conditions and circumstances. Records of the mine works should also be maintained as part of the post-closure plan.

Closure and post closure plans should include appropriate aftercare and continued monitoring of the site, pollutant emissions, and related potential impacts. The duration of post-closure monitoring should be defined on a risk basis; however, site conditions typically require a minimum period of five years after closure or longer.

The timing for finalization of the MRCP is site specific and depends on many factors, such aspotential mine life, however all sites need to engage in some form of progressive restoration during operations. While plans may be modified, as necessary, during the construction and operational phases, plans should include contingencies for temporary suspension of activities and permanent early closure and meet the following objectives for financial feasibility and physical / chemical / ecological integrity.

Financial Feasibility

The costs associated with mine closure and post-closure activities, including post-closure care, should be included in business feasibility analyses during the planning and design stages. Minimum considerations should include the availability of all necessary funds, by appropriate financial instruments, to cover the cost of closure at any stage in the mine life, including provision for early, or temporary closure. Funding should be by either a cash accrual system or a financial guarantee. The two acceptable cash accrual systems are fully funded escrow accounts (including government managed arrangements) or sinking funds. An acceptable form of financial guarantee must be provided by a reputable financial institution. Mine closure requirements should be reviewed on an annual basis and the closure funding arrangements adjusted to reflect any changes.

Ref: IFC (2007)

The IFC Guidelines state that a mine closure plan should incorporate both physical rehabilitation and socio-economic considerations which, by implication, includes the social aspects in the financial surety. There is some ambiguity as to whether a single fund should be established to include both the physical and social aspects of mine closure or if they should be handled separately. This is discussed in more detail in Chapter 5.

Some jurisdictions have developed extremely detailed supporting documentation to assist companies in establishing accurate estimates for the financial surety. In a number of cases this information is available on the internet and this has been identified in the text where relevant. These and other useful website addresses are contained in the Annex 1.

Chapter 2 identifies the main financial surety instruments and the mechanisms for their implementation. Chapter 3 presents case studies from existing jurisdictions. Chapter 4 discusses all the various aspects of the implementation and management of financial sureties, based on the case studies presented in Chapter 3. Chapter 5 summarizes the findings of the study and provides recommendations on the implementation and management of financial sureties. Chapter 6 is an amalgamation of thoughts and comments that emerged during the course of the work.

Box 1.2 on the following page summarizes the standards that should be taken into consideration when establishing financial surety procedures. These were formulated by a senior research associate with the Mineral Policy Center, a U.S. based non-profit environmental organization dedicated to protecting communities and the environment from the impact of irresponsible mining.

The author would like to thank all the people who so generously gave their time to fill in the questionnaire and answer questions. A number of people went out of their way to provide additional information and personal comments all of which have contributed to the writing of this report. In particular, the author would like to thank Ian Wilson and Gavin Murray for their very helpful insights into the current status and thinking behind financial sureties.

Box 1.2: FINANCIAL SURETY STANDARDS

Closure costs: Financial assurances must cover the operator's cost of reclamation and closure as well as redress any impacts that a mining operation causes to wildlife, soil, and water quality. The bond should also cover the cost of a post-closure monitoring period. To accurately compute the level of financial assurance, reclamation and mitigation activities should be clearly spelled out in the operation plan. In addition, the bond should cover the costs of addressing impacts that stem from the operator's failure to complete reclamation, such as the need for long-term treatment of surface and groundwater, environmental monitoring and site maintenance. During mining, assurance levels should be subject to periodic reviews, in order to allow regulators to adjust operators' assurance amounts upward or downward as clean-up needs, environmental risks, or economic factors dictate.

Liquidity: All forms of financial assurance should be reasonably liquid. Cash is the most liquid asset, but high-grade securities, surety bonds and irrevocable letters of credit can serve as acceptable forms of assurance. However, assets that are less liquid, particularly the mine operator's own property or equipment should not be considered adequate assurance, since these items may quickly become valueless in the event of an operator default or bankruptcy.

Accessible: Financial assurances should be readily accessible, dedicated and only released with the specific assent of the regulatory authority, so that regulators can promptly obtain funding to initiate reclamation and remediation in case of operator default. Forms of financial assurance should be payable to regulators, under their control or in trust for their benefit, and earmarked for reclamation and closure. Further, such financial assurances must be discreet legal instruments or sums of money releasable only with the regulatory authority's specific consent.

For their part, regulators must obtain financial assurance up front before a mine project is approved. While regulators, as determined by their periodic reviews, must have the authority to secure financial assurance during the course of mining, waiting until late in the mining process to obtain substantial assurance is unwise, since reduced cash flows at this stage may make it difficult for operators to secure bonding from a surety, bank, or other guarantor.

Healthy guarantors: To assure that guarantors have the financial capacity to assume an operator's risk of not performing its reclamation obligations, regulators must carefully screen guarantors' financial health before accepting any form of assurance. Any risk sharing pools should also be operated on an actuarially sound basis. Regulators should require periodic certification of these criteria by independent, third parties. Public involvement: Since the public runs the risk of bearing the environmental costs not covered by an inadequate or prematurely released bond, the public must be accorded an essential role in advising authorities on setting and releasing of bonds. Therefore, regulators must give the public notice and an opportunity to comment both before the setting of a bond amount and before any decision on whether to release a bond. No substitute: Any financial assurance should not be regarded as a surrogate for a company's legal liability for clean-up, or for the regulators' applying the strictest scrutiny and standards to proposed mining plans and operations. Rather, a financial assurance is only intended to provide the public with a buffer against having to shoulders costs for which the operator is liable.

Ref: Da Rosa (1999)
Note: The author has used the terms 'financial assurance' and 'bond' to refer to a financial surety. The term 'bond' does not refer to a Surety Bond as described in Chapter 2.2.

2 FINANCIAL SURETY INSTRUMENTS

Financial surety is an important tool in ensuring that funds are available to guarantee effective mine closure and rehabilitation. Choosing the appropriate financial surety instrument is critical to making certain this tool is effective. There are a number of different financial surety instruments available and the choice is dependent on the financial strength of the company, the amount of surety required and the time frame over which the fund will need to be in place. It is also essential that the financial surety is quarantined from other company assets, so that it is still available in the event of bankruptcy, and from government abuse.

This Chapter describes the most common forms of financial surety instruments. An evaluation of the most commonly used financial instruments is presented in Box 2.1, taken from the Guidelines on Financial Guarantees and Inspections for Mining Waste Facilities written by MonTec for the European Commission. At the time of publication, these Guidelines had not been adopted by the EC. Chapter 5 provides some comments on the different types of financial surety instruments.

2.1 LETTER OF CREDIT

An irrevocable Letter of Credit, also known as a Bank Guarantee, is an unconditional agreement between a bank and a proponent in order to provide funds to a third party on demand. In this instance, the third party is the relevant government department. A Letter of Credit includes the terms and conditions of the agreement between the proponent and the government, with reference to the rehabilitation program and the agreed costs. Any changes to the Letter of Credit require the consent of all parties involved.

To obtain a Letter of Credit, the proponent will have to demonstrate to the bank that provisions have been made for the rehabilitation of the site and that it has sufficient funds or liquidity to cover the costs. A Letter of Credit is usually issued for a year and renewed annually following a review of rehabilitation requirements and costs. If the bank, for any reasons, will not renew a Letter of Credit, and the proponent fails to provide an acceptable alternative form of surety, then the government can request payment for the full outstanding amount of a Letter of Credit.

The government will usually specify from which banks it will accept a Letter of Credit. The annual cost of a Letter of Credit ranges from 0.5% to 9% of the guaranteed amount, depending on the proponent's credit rating. The funds held in a Letter of Credit do not generate any interest.

2.2. SURETY (INSURANCE) BOND

A Surety Bond, which may also be called an Insurance Bond or a Performance Bond, is an agreement between an insurance company and a proponent in order to provide funds to a third party under certain circumstances. In this instance, the third party is the relevant government department. A Surety Bond will include the terms and conditions of the agreement between the proponent and the government, with reference to the rehabilitation program, the agreed costs and the conditions for the release of the bond. Any changes to a Surety Bond require the consent of all parties involved.

Box 2.1: Evaluation of Commonly Used Financial Surety Instruments

Instrument	Advantages	Disadvantages
Self-bonding(Company Guarantee)	Most advantageous for mining company. Does not tie up capital. Simple to administrate. Public availability of Annual Reports	Even very large companies can fail, no matter what their financial health was when mining project started. Annual Reports and financial statements are not immune to manipulation(accounting scandals)Problematic public acceptance.
Insurance Policy(Scheme)	Low costs also to smaller mining companies. No tied-up capital. Modest cash outflow from mine Operator	Only very few insurance products are currently on the market. Reluctance of large insurers to cover environmental liability risks
Letter of credit, bank guarantee	Cheap to set up (provided that company meets the bank's requirements)No tied-up capital. Modest cash outflow from mine operator. Less administrative requirements. The government can reserve the right to approve banks from which they accept an LOC, thereby minimizing the risk of failure of weak banks	Surety provider (bank, surety company)itself may fail. Obtaining an LOC may reduce the borrowing power of the mining Company. Availability of bonds depends on state of surety industry and may be negatively affected by market forces outside the mining industry.
Surety bond	Generally low costsNo tied-up capital	Bond issuer may fail over the long term(see also under "LOC")Rating of the company that determines the cost and it will be substantially higher for small companies, especially those without proven track records
Cash deposit	Cash is readily available for closure and rehabilitation. Investment-grade securities(treasuries) can be traded with minimal risk of liquidity High public acceptance ("visibility" of guarantee)	For small and junior mining companies, if they fail to meet the criteria of a bank. Can be dissolved only partly in case of need. Can be transferred in a pooled fund. Significant capital is tied up for the duration of the mine life, especially for large mining projects. Some governments may be tempted to use the deposited cash for purposes other than securing the mining project Cash is more vulnerable to being lost to fraud or theft.
Trust fund	High public acceptance ("visibility" of trust fund)Trust funds may appreciate in value(but may also lose value, see "Disadvantages")	Risk of bad management of the trust fund (loss of value if fund invests in risky assets)Trust fund may not have enough value accumulated through annual payments if mining project ceases prematurely Trust fund management and administration consumes some of the value and income earned.

Ref: Montec (2007)

A Surety Bond is issued by an insurance company that should be licensed under the relevant legislation. It is issued for a specific time period and can be renewed for further time periods, based on a credit review of the proponent. During this process the amount of a Surety Bond can be increased or decreased depending on the amendments to the rehabilitation program. If a Surety Bond is not renewed, and the proponent fails to provide an acceptable alternative form of surety, then the government has the option of drawing the full amount. The proponent should be responsible for all fees and charges associated with a Surety Bond.

The government must ensure that a Surety Bond is unconditional and not invalidated by any action or failure of the proponent to act in accordance with the terms of the bond or the legislation.

2.3. TRUST FUND

A Trust Fund, which may also be known as a Mining Reclamation Trust, a Qualifying Environmental Trust or a Cash Trust Fund, is an agreement between a trust company and the proponent for the sole purpose of funding the rehabilitation of a site. In addition to a Trust Fund, there should be a signed agreement between the proponent and the government, administered by the trust company that stipulates the proponent's responsibility with regard to the trust. This agreement should specify that a Trust Fund is to provide security for the rehabilitation costs for a particular site, the total amount required and an outline schedule of payments.

A Trust Fund should be maintained by a company that is licensed under the relevant legislation. The types of investment available to the fund manager should be decided by the proponent and the government, and specified in the agreement. If the payments are not made to a Trust Fund, and the proponent fails to provide an acceptable alternative form of surety, then the government has the option of drawing the full amount of the fund. The proponent should be responsible for all fees and charges associated with a Trust Fund. Contributions to a Trust Fund would usually be structured as a series of payments over a specific time period. The management and performance of a Trust Fund should be subject to periodic review.

The Appendix of the ICMM report, Financial Assurance for Mine Closure and Reclamation (2005), contains a list of the principles, established by the mining industry, for the design, operation and review of a Trust Fund. These are reproduced in full in Box 2.2 and 2.3. The complete report is available on the ICMM website (see Annex 1).

2.4. CASH, BANK DRAFT OR CERTIFIED CHECK

A deposit can be made for a financial surety as Cash, a Bank Draft or a Certified Check. The funds should be placed in a special purpose account under the management of the financial institution with the government and company holding joint signatory powers. Alternatively, the cash can be used to purchase a certificate of deposit which can be pledged to the relevant government agency. Most commercial banks would charge nominal fees for setting up such accounts and the money would attract interest which would accrue to the fund.

2.5. COMPANY GUARANTEE

A Company Guarantee, which may also be called a Corporate Financial Test, a Balance Sheet Test or a Self Guarantee, is based on an evaluation of the assets and liabilities of the company and its ability to pay the total rehabilitation costs. A Company Guarantee requires a long history of financial stability, a credit rating from a specialized credit rating service and at least an annual financial statement prepared by an accredited accounting firm. Many jurisdictions will no longer accept a Company Guarantee as a form of financial surety because of the public perception that a self guarantee for a mining company is a contradiction in terms. Of those that do allow a Company Guarantee, some will only accept this form of financial surety for the first half of the life of the project or for part of the surety.

Box 2.1: Criteria for the efficient design of a trust fund

Site-specific basis for fund	Each mine should be assessed individually and the security required should reflect the costs and risks associated with reclaiming that site.
Basis for cost estimates	Estimated costs should be based on careful engineering and technical studies accompanied by formal risk assessments to take into account the probabilities and consequences of alternative scenarios.
Responsible management of reclamation	The design of the fund should encourage miningcompanies to manage their reclamation programs in an active and responsible manner, in order to control costs and to develop innovative technical solutions to reclamation challenges.
Similarity to pension fund	The principles for setting up a fund should be similar to those used to establish a pension fund.
Investment policy	Investment policy should permit investments that optimize the risk-return ratio, bearing in mind that the fund is a long-term investment.
Investment manager	The fund should be managed by an investmentmanager selected by the company. The companyshould at the same time have the option of managing the fund internally with reasonable guidelines, as with a pension fund.
Monitoring legislation	Legislation modeled on pension statutes or other similar legislation can be used to monitor performance of the fund and to ensure compliance with investment policy.
Choice of financingmechanism	As justified by the circumstances, a company should have the option to determine which government authorized financing mechanism (or combination of mechanisms) represents efficient use of the company's capital.
Expenses deductible for tax	Where a government-mandated mine reclamation fund is required, payments into the fund should be allowed as a deductible expense at the time they are made for purposes of income tax and mining taxes.
Fund income sheltered from tax	Income generated by a fund should be tax-sheltered until withdrawn.
Investment management fees	All investment management costs should be financed from the proceeds of the fund.
Fund Trustee	An independent third party, such as a trust company, is an acceptable trustee of a fund.
Sole government control	The mining industry is opposed to the government having sole control over the management of investments in a fund.

Ref: ICMM 2005

Box 2.2: Guidelines for the review and audit of a trust fund

Site-specific basis for fund	Each mine should be assessed individually and the security required should reflect the costs and risks associated with reclaiming that site.
Basis for cost estimates	Estimated costs should be based on careful engineering and technical studies accompanied by formal risk assessments to take into account the probabilities and consequences of alternative scenarios.
Periodic review or audit	A periodic review or audit of activities of a fund is necessary to ensure appropriate disbursement and use of funds pursuant to the approved decommissioning plan.
Scope of audit	An audit would include the preparation of financial statements and a technical review of work performed. It should also include, where applicable, a reassessment of reclamation requirements and funding contributions.
Conduct of audit	An appropriate panel should be engaged to undertake the review and audit, using technical, engineering, legal and actuarial expertise.
Frequency	A review should be held with a stated frequency, which could be from three to five years, or more frequently if deemed desirable by the government or the company.
Disposition of surplus funds	Any surplus funds determined by a review should be returned, net of appropriate tax adjustments, to the company.

Ref: ICMM 2005

2.6. INSURANCE SCHEME

There are a wide range of insurance options but, until recently, none have been specifically designed to cover long term rehabilitation costs. General forms of insurance, such as premium financing, commercial general liability and professional indemnity do not normally cover environmental liabilities. One major advantage of an Insurance Scheme is that premiums paid into a policy are usually tax deductible.

In the US, one insurance company set up a custom designed product that is a combination of three products; a conventional Surety Bond, accumulation of cash within the policy and insurance protection for overruns and changing requirements. The policy is based on the rehabilitation plans and projected costs, the credit worthiness of the proponent and the market value of the mine assets. From the funds deposited the insurance company issues the required security bonds to the government and pays the actual rehabilitation costs. At the end of project life, if there is a surplus in the account, it goes back to the proponent. If there is a deficit the insurance company pays.

2.7. UNIT LEVY

The Unit Levy option requires the financial surety to be paid in regular installments, the payments being based on the amount of ore or waste mined or milled. The level of payments per tonne would be calculated on the proposed life of the mine, the estimated closure costs and the mining rate. The financial surety payments can be Cash, Letter of Credit or Surety Bond. The proponent would make payments to the fund until the full amount of the financial surety had been reached. In some jurisdictions it is required that the financial surety would be paid in full before the half life of the mine. Signed financial assurance agreements should be included with a closure plan incorporating the terms and conditions for the amount/tonnes, form and timing of the payments.

2.8. SINKING FUND

A sinking fund is a method of incremental payments into a Letter of Credit, Surety Bond or Cash financial surety. A schedule of payments is established at the time of setting up the financial surety. The proponent would then make payments into the fund until the full amount of the financial surety had been reached. In some jurisdictions it is required that the financial surety would be paid in full before the half life of the project. Signed financial assurance agreements should be included with a closure plan when the proponent provides financial assurance in the form of a sinking fund. The agreements include terms and conditions as to the amounts, form and timing of the payments.

2.9. PLEDGE OF ASSETS

In some jurisdictions a Pledge of Assets is an acceptable form of financial surety. This takes the form of all surplus equipment and scrap metal that remains at mine site after operations have ceased. The surplus equipment includes all stationary equipment and buildings. The scrap metal includes all metal debris produced during site demolition and the clean up process.

If a Pledge of Assets is being used as a financial surety several factors should be taken into consideration. These include that the assets are free and clear of encumbrances, that the assets are fixed and not easily moved, that the assets are not contaminated and that there is a market demand for the assets. The value estimation must be carried out by a third party, should include the cost of retrieval and transportation from the site to the market place and be recalculated periodically. However, this is generally viewed as a high risk form of financial surety and is not accepted in many countries.

2.10. FUND POOL

In some jurisdictions the industry is permitted to set up a Fund Pool that receives contributions from all the mining operators in the region and is managed by the industry. However, this is not a particularly popular form of financial surety as it is largely out of the control of the government and it can result in responsible companies subsidizing irresponsible ones.

2.11. TRANSFER OF LIABILITY

Some research has been carried out into the possibility of establishing a specialized company specifically to carry out mine site rehabilitation. This company would have a contractual arrangement with the mining company involved and would be responsible for providing insurance cover. As far as the author could establish, this form of financial surety is not currently available in any jurisdiction.

3 CASE STUDIES

3.1. ONTARIO

3.1.1. Legislation and Governance

In Ontario (Canada) the *Mining Act R.S.O. 1990 (Bill 26, proclaimed 1991), Chapter M. 14, Part VII* covers the rehabilitation of mine land, the requirement for the proponent to submit a closure plan and for a financial assurance to be part of the closure plan. The *Ontario Regulation 240/00*, adopted under *Part VII of the Mining Act,* specifies the standards, procedures and requirements for site rehabilitation and the closure plan, including the financial assurance. Schedules 1 and 2 of these Regulations provide details of the rehabilitation requirements and the information to be included in a closure plan. The latter includes detailed costs for the implementation of the rehabilitation measures and monitoring programs and the form and amount of financial assurance. Financial surety is required for any advanced exploration1 or mining project.

The Government has also produced a *Financial Assurance Policy Index*that is available on the Ministry of Northern Development and Mines website (see Annex 1). This index is designed to aid in the understanding of the administration of the financial assurance provisions of the *Mining Act*. Templates for a Letter of Credit and Surety Bonds are also available to the proponent (Annex 2 and 3).

The Ministry of Northern Development and Mines is responsible for the administration of the *Mining Act*. All aspects of mining are handled by the Mines and Minerals Division, Mineral Development and Lands Branch, including mine closure and financial surety.

3.1.2.Timing

The *Mining Act*, Sections 139-144, specifies that a closure plan must be submitted, filed and approved before the start of advanced exploration or mine production. Section 145 then goes on to stipulate that the financial assurance is required as part of the closure plan. This means that a mining lease can be issued prior to the filing of the closure plan but that the closure plan, including the financial surety, must be filed and approved before any work can start on site.

3.1.3.Financial Surety Instruments

The *Mining Act*, Section 145, identifies the following mechanisms acceptable as financial surety:

- Cash
- Letter of Credit
- Surety Bond
- Trust Fund
- Corporate Financial Test (Company Guarantee)

Or any other acceptable form of security or guarantee including pledge of assets, sinking fund or royalties per tonne, at the discretion of the Director of Mine Rehabilitation.

1 “advanced exploration” means the excavation of an exploratory shaft, adit or decline, the extraction of prescribedmaterial in excess of the prescribed quantity, whether the extraction involves the disturbance or movement ofprescribed material located above or below the surface of the ground, the installation of a mill for test purposes or any other prescribed work; (“exploration avancée”)

In Ontario there are currently 154 financial surety forms for 144 approved reclamation (closure) plans. The breakdown of these sureties is as follows:

- 57% Letter of Credit
- 12% Corporate Financial Test
- 26% Cash/Cash Levy
- 3% Pledge of Assets
- 2% Surety Bond

It is interesting to note that, even though the Corporate Financial Test only accounts for 18 of the total number of forms, it accounts for 67% of the funds being held for financial surety.

3.1.4.Scope of Financial Surety

The *Ontario Regulation 240/00*, Section 4, states that all those engaged in rehabilitation shall comply with the standards, procedures and requirements of the *Mine Rehabilitation Code*set out in Schedule 1. The Regulations, Section 11, go on to say that a closure plan shall include at least the items and information set out in Schedule 2. A summary of the minimum rehabilitative measures referred to in the Code is given in Section 24. The financial surety must be sufficient to cover the following elements of closure:

- Mining infrastructure
- Underground mines
- Adits
- Open pits
- Tailings storage facilities
- Surface and ground water monitoring
- Acid drainage
- Physical stability
- Revegetation

The financial surety must also cover any long term care requirements. The legislation does not specify the inclusion of costs for administration and management of the financial surety but, if the calculations are based on third party costs, these should be automatically included.

3.1.5.Level of Financial Surety

The level of financial surety is based on the cost of using external contractors. The figures are established by the proponent, and their consultants, according to Schedules 1 and 2 in the *Ontario Regulation 240/00*. They must be based on the market value costs of the goods and services required by the work. The level of the financial surety must comprise the end of project costs though payments may be phased in. Incremental contributions may be made via a Sinking Fund. In this instance a schedule offinancial surety payments would be established so that the full amount had been lodged before the half life of the mine, or sooner if feasible. Incremental payments are not available for advanced exploration projects or most higher risk projects.

3.1.6.Tax

There are no tax breaks offered in Ontario for financial sureties. The government does not consider them as an expense as the funds will be returned to the company when they have completed the closure plan.

3.1.7.Review

The proponent’s senior executives must certify that the financial surety is sufficient to cover the closure of the site as per the legislative requirements. The government carries out a quick overview and compares the costs with other projects, but this is not done in any detail. There is no third party involvement or verification. The *Mining Act*, Section 143, requires that any amendments made to the closure plan must include amendments to the financial surety, if the amount needs increasing. Amendments to the closure plan may be made voluntarily by the proponent or at the request of theauthorities. The government is in the process of considering introducing a regular review of closure costs, either every three or five years and, if necessary, adjustment of the level of the financial surety. This review would be carried out by the proponent and their consultants.

3.1.8.Release

Funds are not available to the proponent for on-going rehabilitation. If a company carries out progressive rehabilitation the government may agree to return some of the financial surety. This is based on a certified technical report stating that the work was carried out in accordance with the legislative requirements and the current value of the remaining rehabilitation work. Following successful closure, the funds are returned to the proponent. Some funds may be retained for short term monitoring costs or long term care.

3.1.9.Experience

The Province of Ontario has had the requirement for a financial surety in place since 1991. Since this date, five exploration sites and mines have closed that had a fund in place. In the majority of these cases the companies closed out the site using their own funds and in several cases the financial surety was returned to the company where there were no long term care requirements. In a couple of instances companies, which shut down operations due to economic difficulties, had financial sureties based on a royalty per tonne (Unit Levy). The government was then left with a deficit in the level of fund required to compete closure of the site.

3.2. NEVADA

3.2.1.Legislation and Governance

Mining on federal land in the United States of America is governed by the 1872 federal law titled '*An Act to Promote the Development of Mineral Resources of the United States*'. Most details regarding the procedures for a project on federal land are left to the individual state, providing that state laws do not conflict with federal laws. As 85% of land in Nevada is federal land, the majority of mining projects are governed by the 1872 law and related United States Codes (USC) as well as Nevada State Law. Most of the federal land is managed by the Bureau of Land Management (BLM) and the US Forest Service (USFS).

The relevant federal codes for the BLM are *USC Title 30, 'Mineral Lands and Mining 1970', Title 43, Chapter 35, 'Federal Land Policy and Management 1976'* and the *Code of Federal Regulations (CFR) Title 43, 'Public Lands'*. Sections 3809.500 to 3809.560 (CFR 43) outline the financial guarantee requirements for all mining projects on BLM managed land that cause surface disturbance by more than casual use. The relevant federal codes for the USFS are the *Organic Act 1897*, *USC Title 16, 'National Forest Management Act'* and *36 CFR, 'Parks, Forests, and Public Property'*. 36 CFR 228 requires an operator to file a plan of operations and, when required, lodge a financial surety. The USFS has produced a Reclamation Bond Estimation and Administration Guideline (2004) for mining operationsauthorized and administered under 36 CFR 228A available on its website (see Annex 1). The state legislation relating to mine closure is contained in the *Nevada Revised Statutes (NRS) 445A, Water Pollution Control*, and *NRS 519A, Land Reclamation*. Regulations adopted under these Statutes are incorporated in the *Nevada Administrative Codes (NAC) 445A and 519A.* *NRS 519A* requires that any application for an exploration or mining project should include a bond or other surety. The details of this obligation are contained in *NAC 519A*. Projects of less than 5 acres, or mine production of less than 36,500 tons (includes all ore, waste etc), are not required to lodge a financial surety.

The Nevada State Government has signed a Memorandum of Understanding with the federal land managers (Bureau of Land Management and US Forest Service) to coordinate the administrative and enforcement obligations pertaining to the reclamation of land disturbed by exploration or mining activity. The agency responsible for site reclamation and the financial surety is the Nevada Bureau of Mining Regulation and Reclamation, Division of Environmental Protection, Department of Conservation and Natural Resources and *NRS/NAC 519A*is the primary legislation. This arrangement avoids duplication.

3.2.2.Timing

The *NRS/NAC 519A*requires that an application for an exploration or mining permit should include in writing the assumption of responsibility for the reclamation of the site, a reclamation plan and evidence of a financial surety. The exploration or mining permit, and the reclamation permit, may be issued but are not effective until the financial surety has been accepted.

3.2.3.Financial Surety Instruments

The type of financial surety accepted by Nevada State Law is specified in the *NAC 519A*.
They include the following:

- Trust Fund
- Surety Bond
- Letter of Credit
- Insurance
- Corporate Guarantee

Or any combination of these mechanisms. Large companies may obtain a state Corporate Guarantee for up to 75% of the value of the surety if they can meet regulatory criteria to demonstrate adequate financial health. In addition, the Nevada Bureau administers a Bond Pool that guarantees up to US$ 3 million reclamation costs for small companies that have been refused commercial support. Smaller operations may also be allowed to fund the surety with a Cash Deposit. The recently revised Section 3809 Regulations (43 CFR) do not allow any new or expanded Corporate Guarantees on BLM managed land, though existing guarantees are recognized.

Of the 214 mining and exploration projects that currently have a financial surety in place the breakdown is as follows:

- 23% Surety Bond
- 56% Letter of Credit
- 17% Corporate Guarantee
- 2% Cash Deposit
- 1% Certificate of Deposit
- 1% Bond Pool

The Nevada Bureau currently holds US$ 785 million in mining reclamation bonds.

3.2.4.Scope of Financial Surety

The Nevada legislation states that the financial surety must be sufficient to cover the cost of all aspects of physical closure and include administrative and contingency costs. The physical closure includes:

- The removal of all plant and equipment
- The demolition and disposal of infrastructure
- Stabilization and regrading of surfaces
- Erosion control
- Revegetation
- Process fluid stabilization
- Interim fluid management

The funds must also cover ongoing or long term care required to maintain the effectiveness of reclamation or are necessary in lieu of reclamation. The stabilization of fluids from non-process components (for example seepage from waste rock dumps) and unspecified contingencies are not included.

3.2.5.Level of Financial Surety

The financial surety must be based on third party costs using government rates. The level of surety is established by the proponent, in accordance with the regulatory requirements, and all sources of estimates and calculations must be submitted to the Nevada Division of Environmental Protection.

The Bureau has produced a Reclamation Bond Checklist in order to assist the proponent in calculating the engineering and environmental costs. This document specifies that the administrative costs should be established at 10-15% of the contract cost. The department recommends that all operators should use the Nevada Standardized Reclamation Estimator Model to demonstrate how costs were established. The model is available on its own website (see Annex 1).

Incremental payments for the financial surety are accepted as long as the amount of the fund at any given time covers the outstanding reclamation obligation. These payments are usually only applicable to larger projects and payment would be made at each subsequent phase of operations.

3.2.6.Tax

The state of Nevada, in line with federal policy, allows a deduction of the financial surety for tax purposes. The expense of maintaining a financial surety (premiums etc) are counted as an expense and are tax deductible as well as actual expenditure on rehabilitation. The company is allowed to distribute the financial surety payments over a number of years for tax reduction purposes.

3.2.7.Review

The proponent submits the reclamation cost estimates to the Nevada Division of Environmental Protection. These costs are reviewed internally or jointly with the federal Bureau of Land Management or US Forest Service if public land is involved. They are also subject to public review and comment but are not verified by a third party. The level of financial surety may be reviewed and revised at any time. A full review is carried out at least once every three years and whenever the reclamation plan is modified. If the proponent is paying the financial surety in increments then more frequent reviews are carried out.

3.2.8.Release

Funds are not available to the proponent for on-going rehabilitation but, as discrete steps in the reclamation plan are completed, partial release of the surety may be allowed. Following successful closure the funds are returned to the proponent unless there is a long term outstanding obligation such as perpetual water treatment. In this case a special arrangement may be made such as a self-perpetuating fund.

3.2.9.Experience

The State of Nevada initiated the requirement for a financial surety in 1990. Since this date about 75 exploration sites and mines have closed that had a fund in place. In addition, about 25 sites have been abandoned because of the failure of the operator. In the majority of these latter cases, the funds were not sufficient to pay for all the required reclamation, and the State had to priorities the work and find alternative funds to complete the closure requirements. The main reason why these funds were insufficient to carry out all the necessary reclamation work was they were older sites, run by financially marginal operators that had inadequate surety to begin with. On most of these sites, the regulatory agencies were working to increase the surety, but the operators were unable or unwilling to do soprior to bankruptcy and abandonment.

3.3. QUEENSLAND

3.3.1. Legislation and Governance

The *Mineral Resources Act 1989*provides the framework for the application and granting of mining titles. The *Environmental Protection Act 1994*requires all mining related activities to be issued with an Environmental Authority and for mining projects to produce an Environmental Management Plan, which must include a rehabilitation program. In addition, both laws have provisions for a financial security to be lodged though neither specifically mentions closure plans.

In 2001 the Queensland Government transferred the responsibility for the environmental regulation and management of mining from the Department of Mines and Energy (DME) to the Environmental Protection Agency (EPA). This required the repeal of the environmental provisions contained in the *Mineral Resources Act*and the insertion of a new chapter in the *Environmental Protection Act*. These changes were implemented by the *Environmental Protection and Other Legislation Amendments Act 2000*. Under this new legislation, the Minister of Mines lost most powers in the environmental decision making process but retained the right to make representations if an objection is lodged against a new mining project or a refusal is likely.

The *Minerals Resources Act*requires that a 'security' is deposited prior to a mining title being issued. This is for non-compliance with the title conditions and 'improvement restoration' but no longer covers rehabilitation. The *Environmental Protection Act*requires the rehabilitation program to include the proposed amount of the financial surety for larger projects while the Codes of Environmental Compliance require a financial surety for small projects. A financial surety is required for all mining titles but the proponent may lodge a single surety to cover the requirement of both the *Mineral Resources Act*and the *Environmental Protection Act*.

The DME is responsible for granting, and for the surrender of, all mining titles. The EPA is responsible for granting, and for the surrender of, an Environmental Authority. The DME is responsible for the receipt and management of both the security under the *Mineral Resources Act*and the financial surety under the *Environmental Protection Act*. Under the *Environmental Protection Act*, the EPA has produced a number of Guidelines and Codes which contain the detail of the environmental management of all mining projects. Of particular relevance is Guideline 17: Financial Assurance for Mining Activities (2003). All legislation is available through links on the EPA website (see Annex 1).

3.3.2. Timing

An application for a mining title must be accompanied by a completed application for an Environmental Authority (mining activity). For all mining licenses, except a mining lease, the financial surety must be lodged before the title is granted. In the case of a mining lease, the financial surety does not need to be lodged until after the mining title and the Environmental Authority have been granted. However, it must be in place before any activity proposed in the Plan of Operations is carried out on site.

3.3.3. Financial Surety Instruments

The *Environmental Protection Act*gives the EPA discretion to determine the form of financial surety. Guideline 17 specifies that the acceptable forms of financial surety include:

- Cash
- Bank Guarantee (Letter of Credit)
- Insurance Bond

Queensland currently has about 1,000 financial sureties for mining claims, 1,000 for exploration permits, 200 for mineral development licenses and 1,200 for mining leases. Approximately 70% of the mining lease sureties are Cash and 30% Bank Guarantees, though the latter represent 98.5% of the total amount of financial surety held by the department.

3.3.4.Scope of Financial Surety

The Queensland legislation does not specify what aspects of mine closure are encompassed by the term rehabilitation or what should be covered by the financial surety. The elements identified by the EPA that could be included under the term rehabilitation are:

- Removal of plant and equipment
- Recontouring waste dumps and pits
- Capping tailings storage facilities and other hazardous materials
- Breaching dams and restoring water courses
- Making slopes and openings safe
- Replacing topsoil
- Revegetation
- Monitoring water and air quality, erosion rates, vegetation
- Conducting contaminated land surveys
- Implementing site management plans

*The Amendment Act 200*and Guideline 17 specify that maintenance and monitoring costs should be included in the financial surety.

In January 2006, new provisions relating to residual risk payments were introduced allowing for a separate cash payment to be made when the Environmental Authority is surrendered or when progressive rehabilitation is certified. This residual risk payment covers future maintenance and remedial work.

3.3.5.Level of Financial Surety

The financial surety for exploration and small (standard) mining projects is based on the total area of disturbance and the risk associated with the rehabilitation. A simplified version of the table from Guideline 17 is shown below.

Table 3.3.1: Financial Surety for Standard Exploration and Mineral Development Projects

Total Area ofDisturbance	Low Risk: simple straight Forwardrehabilitation	High Risk: Difficult rehabilitation
Less than 1 hectare	A$2,500	A$5,000
1 to 4 hectares	A$10,000	A$20,000
4 to 10 hectares	A$20,000	A$40,000

The level of financial surety for a non-standard project is calculated on a project specific basis, even though one project may include a number of leases. It is calculated by using a unit rehabilitation cost multiplied by the estimated disturbed area, based on using third party contractors. The amount is established by the proponent. The Code of Environmental Compliance for Mining Lease Projects contains a worked example to assist the proponent in establishing the costs. The maintenance and monitoring costs are calculated at 10% of the total rehabilitation costs.

The financial surety system allows a discount of 10% to 75% based on previous environmental performance. The maximum discount will be reduced to 30% in January 2009. The performance criteria and discount rates are included in Appendix B, Table 2 of Guideline 17.

The financial surety can be paid incrementally, established by estimating the maximum level of disturbance for each planning period covered by the Plan of Operations. This period can be anything between 1 and 5 years.

3.3.6.Tax

A 10% goods and services tax is payable on all taxable supplies which can be reclaimed if the administering authority makes a claim on the financial surety.

3.3.7.Review

When submitting a financial surety, the holder of the Environmental Authority must also certify that the correct procedures were used. The holder may decide to go to an outside audit but third party verification is not required. However, the penalties for providing false or misleading information can be quite severe (up to two years in prison). The financial surety is reviewed whenever a mining title is renewed or, in the case of a mining lease, when a new Plan of Operations or Environmental Authority is amended or replaced. The time between reviews is governed by the type of mining title. The EPA has the power to reassess the financial surety at any time provide it has good reason to do so. At any of these reviews the level of financial surety can be changed.

3.3.8.Release

The financial surety is not available to the holder of the Environmental Authority for ongoing rehabilitation. However, when a new Plan of Operations plan is submitted, and the rehabilitation liability recalculated, work that has been completed will no longer be included in the total.

The Environmental Authority must be surrendered or cancelled before a mining title can be relinquished. An application for the surrender of the Environmental Authority requires the holder to also submit a final rehabilitation report. The financial surety remains in place until the EPA is satisfied that no further claim is likely to be made against it. At this stage a residual risk payment will be established and the surety surrendered.

3.3.9.Experience

A number of small and medium sized mines have closed since the financial surety system was introduced to Queensland. In some cases the mining title was revoked because of financial failure or non-compliance with the legislation. Several of these have required the government to carry out the rehabilitation work and in two instances the costs have been more than A$ 1 million. Most mines that close through a planned closure process have not required any additional work.

3.4. VICTORIA

3.4.1.Legislation and Governance

In Victoria all mining activity is regulated by the *Mineral Resources (Sustainable Development) Act 1990*and the Extractive *Industries Development Act 1995*and associated Regulations. Both Acts contain the requirement for a Rehabilitation Plan and a financial surety, known as a rehabilitation bond the details for which are contained in the draft Guidelines, Establishment and Management of Rehabilitation Bonds 2007. These Guidelines will replace the 1997 Guidelines. The *Extractive Industries Development Act*regulates quarrying activity while the Mineral *Resources (Sustainable Development) Act* regulates the remainder of the mining industry.

The *Mineral Resources (Sustainable Development) Act*establishes a three stage approval process for mining projects; the Mining License; the Work Plan; and the Work Authority. The Rehabilitation Plan must be submitted as part of the Work Plan. Work on site cannot start until a Work Authority has been granted by which time a rehabilitation bond must have been lodged.

A recipient of a mining license must also follow the planning permit process regulated under the *Planning and Environment Act 1987*. The application for the planning permit must include details of proposed rehabilitation. Under the *Environment Effects Act 1978*, the Minister for Planning may determine that an Environment Effects Statement is required. This statement should also contain the rehabilitation plan.

The Department of Primary Industries (DPI), Minerals and Petroleum Division is responsible for the administration of the *Mineral Resources (Sustainable Development) Act* and the Extractive *Industries Development Act.* The rehabilitation plan must be approved by the DPI and the rehabilitation bond lodged with the Minister for Resources.

3.4.2.Timing

Once a mining title has been issued, in the case of a mining license, the proponent has six months to submit a Work Plan which also includes the rehabilitation plan. This is reduced to three months for an exploration license. The rehabilitation bond must then be lodged before the Work Authority is granted and prior to any work starting on site.

3.4.3.Financial Surety Instruments

The only form of financial surety accepted by the DPI is a Bank Guarantee (Letter of Credit).

3.4.4.Scope of Financial Surety

The Victoria legislation does not specify what aspects of mine closure are encompassed by the term rehabilitation or what should be covered by the financial surety. The *Mineral Resources Development Regulations 2002, Schedule 13*state that a rehabilitation plan should include the following:

- Concepts for the end utilization of the site
- A proposal for the progressive rehabilitation and stabilization of extraction areas, road cuttings and waste dumps, including re-vegetation species
- Proposals for the end rehabilitation of the site, including the final security of the site and the removal of plant and equipment.

The 2007 Guidelines provide a manual for common rehabilitation principles and include possible acceptable methods of treatment. Appendix C.3: Generally Accepted Closure Methods also provides guidance, though rehabilitation plans are done on a site by site basis.

3.4.5.Level of Financial Surety

The Minister for Resources must determine the level of financial surety required and this is done in consultation with the Department of Sustainability and Environment if Crown land is involved. For licenses on private land consultation is with the local council and the landowner. The surety is calculated by the DPI environmental officers, following receipt of the rehabilitation plan, and is based on utilizing third party contractors. The financial surety also includes 10% for project management, 10% for contingency costs and 5% for monitoring. The level of financial surety is established using standard rates for simple operations and the Rehabilitation Bond Calculator (available on the DPI website; see Annex1) for larger, more complex sites. This Calculator is based on the URS/GSSE Rehabilitation Cost estimate Tool (see Chapter 5.5). The final amount of the financial surety is subject to consultation with the proponent but must reflect the actual cost of the proposed rehabilitation.

There is no facility for the initial financial surety to be paid in increments. However, where a substantial surety increase is required, and the proponent has demonstrated that the increase might have a serious impact on the viability of the project, incremental payments of the additional surety may be approved.

3.4.6. Tax

The legislation does not specify the tax position for funds paid into a financial surety.

3.4.7. Review

There is no third party involvement is establishing the financial surety and no process of verification. The DPI has written procedures for establishing bonds which are subject to an internal audit. Individual assessments are checked in all cases by a second officer and further checks apply to the larger sureties. The DPI has also had an external audit of the surety systems by third party auditors and by the State Auditor General.

The frequency that a financial surety is reviewed ranges from every two years for high risk sites to every ten years for low risk sites based on the table contained in the Guidelines. In addition, a financial surety would be reviewed if the proponent changed the work plan or a transfer of assets. The Minister may, at any time, require the proponent to increase the level of the financial surety if the Minister is of the opinion that the existing amount is insufficient. In all cases the review is carried out by the DPI.

According to the 2007 Guidelines, a proponent is now required to submit an annual assessment of the current rehabilitation liability at the end of each reporting period. The assessment will not be used to as an automatic trigger for a financial surety adjustment but may lead to the rescheduling of the next departmental review.

3.4.8. Release

The financial surety funds are not available to the proponent for on-going rehabilitation. The funds may be partially released where progressive rehabilitation has been successful. Following the successful rehabilitation of the site all of the financial surety is returned to the proponent following consultation with the relevant groups.

3.4.9. Experience

In the state of Victoria there are approximately 300 financial sureties in place for operating mines and 180 for exploration licenses, not including quarries of which there are a further 900. All of these financial assurances are in the form of Bank Guarantees (Letter of Credit). Over the last ten years, mines that have closed with a financial surety in place have generally had sufficient funds to cover the closure costs.

The Minerals Council of Australia has commented on the 2007 draft Guidelines and has made the following recommendations:

- That the form of financial surety should be addressed;
- That the initial financial surety should match the liability of the formal review period and not maximum liability for the life of the project; and
- That clarity is required regarding self-assessments using the Calculator and formal bond reviews.

3.5. BOTSWANA

The Government of Botswana is in the process of initiating financial surety requirements for mining projects. The Ministry of Minerals, Energy and Water Resources is actively encouraging mining companies to establish financial sureties for closure separate from the company's other accounts. A discussion regarding the possibility of the government agreeing to tax concessions for the funds is currently taking place. To date, although some of the companies have agreed in principle, no financial sureties have been established.

3.5.1.Legislation and Governance

The *Mines and Minerals Act 1999*provides the framework for the application and granting of a mining license. Part IX of this Act covers the environmental obligations which include the requirement for the holder of a mining license to carry out on-going rehabilitation of the site and to restore the land substantially to the original condition, as far as is practicable and in a manner acceptable to the Director of Mines, at the end of operations. The same section also provides for the proponent to make adequate financial provisions for compliance with the obligations contained in this section.

The *Mines, Quarries, Works and Machinery Act 1978*, the *Waste Management Act 1998* and the *Environmental Impact Assessment Act 2005* also all contain additional mine closure and rehabilitation requirements. However, none of these specifically mention financial surety. The Guidelines for preparing Environmental Impact Assessment Reports 2003 include a financial provision that require a proponent to provide details regarding the ability to fund the Environmental Management Program which includes decommissioning and closure. The Ministry of Minerals, Energy and Water Resources, Department of Mines is responsible for the implementation of mine closure. It is proposed that the Department of Mines and the Ministry of Finance and Development are jointly responsible for the implementation and management of the financial surety for mining projects. The Ministry of Finance isinvolved because it will be housing the institution that will host the fund.

3.5.2.Timing

The financial surety must be in place before the mining title is granted.

3.5.3.Financial Surety Instruments

The form of financial surety is not identified in the legislation and the government is still deciding which types will be acceptable.

3.5.4.Scope of Financial Surety

The legislation does not specify what aspects of mine closure are included by the term rehabilitation or what should be covered by the financial surety. The Department of Mines states that, by default as part of the approved closure program, the financial surety should encompass the closure objective and plan, all rehabilitation costs and post closure monitoring costs.

3.5.5.Level of Financial Surety

The level of financial surety is currently based on existing estimated costs for all elements included in closure activities. The Department of Mines intends to develop guidelines to provide a basis for the calculations.

3.5.6.Review

The financial surety is calculated and submitted by the proponent and then reviewed and approved by the Department of Mines. The level of financial surety may be reviewed and revised whenever there is a change in the operating plan. A full review will be carried out every five years and then a year prior to closure by the department and the proponent.

3.5.7. Release

The method for the release of the financial surety has not yet been established.

3.5.8. Experience

There are currently no financial sureties in place.

3.6. GHANA

3.6.1. Legislation and Governance

The *Mining and Minerals Law 1986*provides the framework for the application and granting of exploration and mining titles. Section 66 of this Law states that a certificate of surrender (of the license) will not be granted if the Secretary "is not satisfied that the applicant will surrender the land in a condition which is safe and accords with good mining practice." *The Environmental Protection Agency Act 1994*makes no specific reference to mining but does allow for regulations to be drawn up to provide for "standards and code of practice relating to the protection, development and rehabilitation of the environment".

The *Environmental Assessment Regulations 1999*, developed under the *Environmental Protection Agency Act*, require that an environmental impact statement for mining shall include reclamation plans and the proponent post a reclamation bond. The Mining and Environmental Guidelines 1994 state that an exploration site should be rehabilitated to a condition consistent with the pre-existing character and utility of the area within three months of abandonment. The Guidelines also require that an initial reclamation plan should be submitted as part of the environmental impact assessment and environmental action plan and gives the government the right to request a reclamation bond. The final reclamation plan must be submitted within the first two years of operation. These Guidelines have been updated (2007) but are not yet available for general release. The Minerals Commission and the Environmental Protection Agency (EPA) are jointly responsible for mine closure and the EPA is responsible for the implementation and management of the financial surety.

3.6.2. Timing

The legislation does not specify when the reclamation bond should be put in place. The EPA currently requires that the bond is lodged after the mining license has been granted.

3.6.3. Financial Surety Instruments

The legislation does not specify which financial surety instruments are acceptable. The EPA lists the following mechanisms as being available to the proponent:

- Bank Guarantee
- Letter of Credit
- Performance Bond
- Insurance
- Cash Deposit

There are currently ten projects that have financial sureties in place. For the majority of these projects approximately 80% to 90% of the surety is in the form of a Bank Guarantee, the remainder is Cash. One company has an Insurance Scheme.

3.6.4. Scope of Financial Surety

The Mining and Environmental Guidelines specify the minimum standards required for the reclamation plan though the legislation does not specify what aspects of mine closure should be covered by the financial surety. These are defined by the EPA as all elements of closure including the transfer of immovable assets to the local authority, the return of the site to pre-mining land use status and the physical and chemical stability of the reclaimed site.

3.6.5. Level of Financial Surety

The level of financial surety is based on the full reclamation costs. It is not specified whether this level is the cost of the work being carried out by the proponent or by a third party.

3.6.6. Review

The financial surety is calculated on the basis of the reclamation plan by the proponent and then submitted to the EPA for approval. Once in place a financial surety is reviewed by the EPA every two years. At the time of the review the level of surety may be adjusted depending on the value of rehabilitation work done by the company during the review period.

3.6.7. Release

The funds contained in the financial surety are not available to the proponent for on-going rehabilitation. The surety is retained for three years following the completion of the reclamation plan and then returned to the proponent in full. This period is extended to seven years if there is the potential for acid mine drainage.

3.6.8. Experience

So far one mining project has been closed that had a financial surety in place. The level of financial surety was sufficient to fund all closure costs.

3.7. PAPUA NEW GUINEA

The Government of Papua New Guinea is in the process of initiating financial surety requirements for mining projects. The previous Department of Mining, now the Department of Mineral Policy and Geohazard Management, produced a draft Green Paper on Mine Closure Regulation and Guidelines that are still under review. The only project that currently has a financial surety in place is the Ok Tedi Mine, which has its own legislation.

3.7.1. Legislation and Governance

The *Mining Act (1992)* and associated Regulations provide the framework for the application and granting of mining titles. Amendments to the *Mining Act* are currently being prepared to insert provisions that require all holders of exploration and mining titles to carry out rehabilitation prior to relinquishing the title. At present there is no requirement in the *Mining Act* for the proponent to produce any form of financial surety.

The Government is currently drawing up *Mine Closure Regulation and Guidelines*, developed under the *Mining Act*. The 2005 draft requires that mine closure planning should be an integral part of all mining operations and that the proponent must establish a Mine Closure Security and a Mine Closure Trust Fund. This requirement is only for mining licenses. Exploration licenses and alluvial mining leases are addressed in the *Environmental Code for Mining* developed under the *Environment Act 2000*and the *Mining Act*. The *Environment Act* allows for an environmental bond to be lodged for any activity that requires an environmental permit.

Discussions are still taking place to establish the exact interaction between the *Mine Closure Regulation and Guidelines* and the *Environment Act*. Current thinking is that, if a financial surety is required under the jurisdiction of the *Mining Act*, then no further cover will be required under the *Environment Act*. However, small alluvial mining leases will still be covered by the *Environment Act*.

The draft *Mine Closure Regulation and Guidelines*allow for a proponent to be exempt from the requirement of providing a financial surety if:

- "it is impracticable for the developer to provide security or such security cannot be provided at an economic cost (having regard to the scale of mining and the financial resources available to the developer); and
- The benefits to the public welfare from the development of the mineral resources outweighs the risk from permitting the project to proceed without sufficient security being provided to support mine closure obligations."

The Mineral Resources Authority (MRA) is responsible for the administration of the *Mining Act*and the Department of Mineral Policy (DMP) is responsible for formulating policies relating to mining activities. This administration is carried out in coordination with the Department of Treasury, Finance and Planning for the financial aspects of the legislation.

The Department of Environment and Conservation (DEC) is responsible for the administration of the *Environment Act* and the environmental bond. Both the MRA and DEC will review and approve the mine closure plan whilst the DMP will approve policies relating to mining activities including mine closure. The Ok Tedi mine is governed by the *Mining (Ok Tedi Agreement) Act 1976*and is amended by Supplemental Agreement Acts. The *Mining (Ok Tedi Ninth Supplemental Agreement) Act 2001*, also known as the *Mine Closure and Decommissioning Code 2001,* establishes the requirement for both closure plans and financial surety. This case is discussed in more detail under the heading 'Experience'.

3.7.2.Timing

The mine closure plan should be submitted with the feasibility study and includes estimated costs for closure and the financial provisions. Both the security for mine closure costs and the Mine Closure Trust Fund must be established before the commencement of construction of the mine but after the mining license has been granted. The legislation does not specify when the environmental bond should be lodged.

3.7.3.Financial Surety Instruments

The draft *Mine Closure Regulation and Guidelines*identifies the following forms of financial surety as acceptable:

- Bank Guarantee
- Parent Company Guarantee
- Insurance Policy
- Cash Deposit

A Mine Closure Trust Fund may be held off-shore at the Mining Advisory Board's discretion. The *Environment Act*states that the environmental bond may be submitted as a Bank Guarantee, Insurance Policy or any other form of security approved by the Director of Environment.

3.7.4.Scope of Financial Surety

The Mine Closure Security will be established at the start of operations and is designed to cover the costs of the technical and physical rehabilitation aspects of premature mine closure. The Mine Closure Trust Fund will accrue during the life of the project and will cover the actual costs of mine closure including decommissioning, rehabilitation and post closure monitoring. The Mine Closure Security will be reduced as the Mine Closure Trust Fund increases. It has not been specified what will be included in the environmental bond.

Any holder of an alluvial mining lease will be required to pay a levy on the sales revenue derived from the activity. This levy will accumulate in a special fund and will be used to remedy a failure by the alluvial miner to comply with the closure guidelines which includes preservation of the environment and removal of mining equipment. It is interesting to note that the draft *Mine Closure Regulation and Guidelines*state that a different mechanism will be established to cover the social implications of closure. This is discussed in Chapter 5.9.

3.7.5.Level of Financial Surety

The level of financial surety is based on the estimated cost of closing the mine and should incorporate premature closure.

3.7.6.Tax

The proponent may write down the contributions to the financial surety as an expenditure relating to mine closure which are tax deductible. Any funds removed from the financial surety other than for the purpose of implementing closure obligations would be recognized as assessable income and subject to tax. Any interest that accumulates in the fund will be used for mine closure. In addition, rehabilitation costs during commercial production may be written down as direct operating costs for tax purposes.

3.7.7.Review

The initial mine closure plan and financial surety is reviewed by the mining and Environment departments. It will then be subject to a periodic audit during the life of the mine by the Project Liaison Committee; every two years, if the remaining mine life is less than ten years, and every five years when the remaining mine life is more than ten years. It will also be reviewed if any material changes are made to the operating plan. These reviews will include the financial surety and take into consideration any changes that are required. The Director of Environment or the Mining Advisory Council may also request a review at any time.

3.7.8.Release

The financial surety funds are not available to the proponent for on-going rehabilitation. Once the agreed completion criteria for closure have been achieved to the satisfaction of the Government, the MRA will issue a closure certificate which is the mechanism for the formal relinquishment of the mining lease. However, depending on the post closure monitoring requirements, as specified in the mine closure plan, the mining lease may not be relinquished for up to 10 years. During this period the proponent is responsible for any additional rehabilitation work. Financial surety is required to support these obligations either through the original security or by provision of a specific fund.

3.7.9.Experience

There are currently no financial sureties in place under the above process. However, the *Ok Tedi Mine Closure and Decommissioning Code (2001)* provides the legal framework for the preparation of a mine closure plan for the Ok Tedi mine. This plan must be updated every 2 years. The *Code* also states that the company must establish a financial assurance to cover the costs of closure include in the plan.

The 2006 draft Mine Closure Plan2 produced by Ok Tedi Mining Ltd (OTML) consists of a detailed description of the physical closure process and the costs involved. It includes the demolition and removal of infrastructure, site rehabilitation, monitoring and aftercare for up to 6 years and redundancy payments. It also includes a 20% contingency and an annual escalator of 3% up to 2013, the forecast mine closure date. The total financial assurance currently stands at US$ 126 million, of which US$ 75.6

has been contributed by OTML (August 2008). The Funds contributed by Ok Tedi are tax deductible, and the interest earned is tax exempt, and are held in a Trust account offshore, administered by a UK bank. The costs were subject to an external audited review in 2003 and an internal unaudited review in 2006.

The mine closure plan includes a social and economic report that focuses on the communities that will be most impacted by mine closure. OTML has established a number of trust funds designed to reduce the immediate impact of premature or planned closure. These funds receive the dividend entitlements, compensation and development money. The company is currently administering 13 Trusts and 7 village funds. There are slightly different arrangements for each fund but in general:

- Some have a cash component;
- Most have a development component – used for infrastructure, education, social activities etc.;
- All have an investment component (future generations fund); and
- Most have tax (GST) exemption status.

All funds are banked in Trust accounts in Papua New Guinea and a Board of Trustees hasbeen established for each fund. The Boards comprise representatives from National andProvincial Government, Council of Churches, OTML and the communities. Resolutionspassed by the Board of Trustees must be unanimous. Up until 2007, OTML has contributed2 The Mine Closure Plan is available on the OTML website (see Annex 1)a total of K800 million to the various trusts. The contributions are made each year in accordance with the agreements. A Trust Administration Department is in place to manage the use of these funds and OTML is looking at how these trusts will be administered post closure to ensure remaining funds continue to benefit the beneficiaries into the future.

3.8. SOUTH AFRICA

3.8.1.Legislation and Governance

In South Africa, the *Minerals and Petroleum Resources Development Act* (MPRDA) 2002, which came into effect in 2004, provides the regulatory environment for the minerals industry. It is supported by the *Minerals and Petroleum Resources Development Regulations 2004*. Environmental management principles are established in the National *Environmental Management Act 1998* (NEMA) and are applicable to all prospecting and mining operations. These serve as guidelines for the interpretation, administration and implementation of the environmental requirements of the MPRDA.

The MPRDA includes the obligation for all prospecting and mining operations to submit an environmental management plan or program and to rehabilitate the affected environment and to make a financial provision for this rehabilitation or management of negative environmental impacts. The *2004 Regulations* specify that an environmental management plan or program must include closure and environmental objectives and a financial provision. This is commonly referred to as the preliminary mine closure plan which is finalized nearer to the decommissioning date.

The environmental aspects of the MPRDA are the responsibility of the Minister of Minerals and Energy and administrated by the Department of Minerals and Energy (DME) at both the national and regional level. Recent amendments to the MPRDA and NEMA, currently waiting for parliamentary approval, will transfer the environmental responsibilities including some closure and financial provisions to the Department of Environmental Affairs and Tourism.

3.8.2. Timing

According to the MPRDA, applicants for a reconnaissance permission, prospecting right, mining right or mining permit must submit, and obtain approval for, an environmental management plan or program prior to the title coming into effect. This plan or program must include details of the financial surety which has to be established prior to approval being granted.

3.8.3. Financial Surety Instruments

The 2004 Regulations specify that the financial surety instruments available to the proponent are:

- Trust Fund
- Bank Guarantee
- Cash Deposit

Or any other method determined by the Director General of the DME. The major mining companies in South Africa generally use trust funds and centralized them at a corporate level.

3.8.4. Scope of Financial Surety

The financial surety is assessed by the DME using the Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine (2005). This Guideline provides a generic approach to the determination of the financial surety for all essential closure components which includes removal of infrastructure, sealing of voids, rehabilitation, water management and post closure maintenance and aftercare. The calculations are based on third party costs and include 12.5% for preliminary and general management and administration and 10% contingency. A master unit rate is determined depending on risk class and area of sensitivity.

3.8.5. Level of Financial Surety

The level of financial surety is based on the assumption that the rehabilitation work will be carried out by a third party employed by the DME. It is not stated but implied that the financial surety may not be paid incrementally. The Evaluation Guidelines include a detailed breakdown of the closure costs with a master rate for each component and a multiplication factor depending on the risk class and area sensitivity. The master rates are updated annually. It has been proposed that prospecting operations attract a flat rate financial surety as follows:

- R 20,000.00 per hectare in low sensitivity environments
- R 50,000.00 per hectare in medium sensitivity environments
- R 80,000.00 per hectare in high sensitivity environments

Where every hectare does not just refer to the disturbed areas but to the whole prospecting area as identified on the title.

3.8.6. Tax

The financial surety should include 14% VAT. Contributions to a trust fund are tax deductible as running costs. The trust funds are exempt provided they are used for the purpose of rehabilitation after decommissioning.

3.8.7. Review

According to the MPRDA, the Minister is responsible for both the assessment of environmental liability and financial surety and may appoint an independent assessor if deemed necessary. This function has been devolved to the regional offices. The Act states that the proponent must assess their environmental liability annually and increase the financial surety to the satisfaction of the Minister.

3.8.8. Release
The financial surety is not available for ongoing rehabilitation. It is released when the Minister has issued a closure certificate but a portion may be retained to cover latent or residual environmental impacts.

3.8.9. Experience
There are some examples of mines closing down prematurely but they were operating under the old regulations. Currently there is generally reluctance on the part of the MPRDA to issue closure certificates.

3.9. SWEDEN

3.9.1. Legislation and Governance
At present the *Minerals Act 1992* and the *Environmental Code 1998* both contain clauses relating to mine decommissioning and rehabilitation and the provision for a financial surety but in very general terms. However, the *Environmental Code* provisions are only applied in practice for quarrying operations. The mining industry has been dominated by three major mining companies that have taken responsibility for mines they have closed negating the need for financial sureties.

The legislation provides very little guidance on what elements should be included in the financial surety, how to calculate the amount or any other details. Over the past five years a number of financial sureties have been required following judicial proceedings but the way in which the provisions have been applied has been quite inconsistent.

The government recently adopted the *European Union (EU) Directive 2006/21/EC on the Management of Waste from Extractive Industries,* which will be implemented in national law in 2008 by amendments to the *Environmental Code*. The *Directive* specifically states the requirement for a mine closure plan, rehabilitation and monitoring and the provision of a financial surety. Technical Guidelines (MonTec 2007) for establishing a financial surety have been developed for the European Commission in accordance with Article 22 of the Directive. The Directive is discussed in more detail in Chapter 3.10. The government body in Sweden responsible for mine closure and the financial surety is the Environmental Court.

3.9.2. Timing
The establishing of a financial surety is part of the licensing procedure and operations may not start until the fund is in place.

3.9.3. Financial Surety Instruments
The *Environmental Code* specifies the acceptable financial surety instruments as a Bank Guarantee or a Pledge of Assets. Cash Funds are also admissible. There are currently 4 or 5 mines with a financial surety in place with an equal division of Bank Guarantees and Cash Funds.

3.9.4. Scope of Financial Surety
The existing legislation does not specify which elements of closure should be included in the financial surety. In principle, all measures included in the closure plan are taken into consideration.

3.9.5. Level of Financial Surety
The existing legislation does not specify the required level of financial surety, how the figures should be established or what aspects should be included.

3.9.6. Review

The level of financial surety is calculated and proposed by the proponent and is reviewed bythe Environmental Court, other relevant authorities and stakeholders as part of the licensingprocedure. There are currently no legal requirements for the financial surety to be reviewed on a regularbasis apart from when a permit comes up for renewal. However, the permitting authoritymay request additional funding if required. The *EU Directive* requires a waste management plan to be reviewed every five years with the size of the financial surety adjusted accordingly. This review will most likely be carried out by the County Administration and then approved by the Environmental Court.

3.9.7. Release

The funds are not available to the proponent for on-going rehabilitation. The funds are released when reclamation has been completed.

3.9.8. Experience

To date no operations have closed with a financial surety in place.

3.10. EUROPEAN UNION

3.10.1.Legislation and Governance

The European Union produces legislative acts, known as *Directives*, which require member states to achieve a particular result without dictating the means of achieving that result. There are a number of EU Directives that are applicable to mining operations; the most specific is *EU Directive 2006/21/EC on the Management of Waste from Extractive Industries*which had to be implemented by 1st May 2008. Article 5 of this Directive requires that an operator draws up a waste management plan which should contain the proposed plan for closure, including rehabilitation, after-closure procedures and monitoring.

Article 14 establishes the need for a financial surety, known as a financial guarantee, to cover the accumulation or deposit of waste. The term 'waste' is defined in Article 1(a) of *European Community Council Directive on Waste 75/442/EEC*and encompasses "any substance or object which the holder disposes of or is required to dispose of". *EU Directive 2006/21/EC*amends *EU Directive 2004/35/EC on environmental liability with regard to the Prevention and Remedying of Environmental Damage*. The latter refers to the 'polluter pays' principal and requires that a financial surety be used to cover the responsibilities under this Directive. Both Directives are supported by a reference document produced by the European Commission in July 2004, Best Available Techniques for Management of Tailings and Waste Rock in Mining Activities, which includes closure methods but only refers to a financial guarantee in the glossary. The European Commission has recently commissioned the production of Guidelines for Financial Guarantees and Inspections for Mining Waste Facilities which will be published on the Directorate General (DG) Environment website (MonTec 2007). The content of these Guidelines does not necessarily represent the formal opinion of the European Commission. All Directives can be ccessed on the EU Database website (see Annex 1).

3.10.2.Timing

Article 14 of *EU Directive 2006/21/EC*specifies that a financial surety should be in place prior to the start of any operation that involves the production of waste.

3.10.3.Financial Surety Instruments

Article 14 also establishes that the financial surety should be in the form of a financial deposit, or equivalent, which may include industry-sponsored mutual guarantee funds.

3.10.4. Scope of Financial Surety

*EU Directive 2006/21/EC*covers the management of waste from land-based extractive industries and includes all waste arising from the prospecting, extraction (including the preproduction development stage), treatment and storage of mineral resources and from the working of quarries. All these aspects of waste must be covered by the financial surety including post closure procedures and monitoring. The financial surety in this Directive does not include the infrastructure and other facilities related to a mining operation or inert waste or unpolluted soil unless deposited in a Category A waste facility (hazardous or dangerous waste or incorrect operation). Some aspects of these exclusions could be covered by the financial surety requirements of *EU Directive 2004/35/EC*though this is debatable.

3.10.5. Level of Financial Surety

The *EU Directive 2006/21/EC*establishes the level of financial surety should be based on third party costs.

3.10.6. Tax

The *EU Directive 2006/21/EC*makes no reference to the tax implications for the financial surety.

3.10.7. Review

It is assumed in the *EU Directive 2006/21/EC*that the financial surety calculations are assessed by a third party. It requires for the waste management plan to be reviewed every five years and provisions to be made to periodically adjust the surety in line with these reviews.

3.10.8. Release

Article 12 of the *EU Directive 2006/21/EC*places the accountability for the waste facility, even after closure, on the operator and they have the duty to keep the regulatory authority informed of any events or developments likely to affect the stability of the site. The financial surety may be released when the competent authority approves closure or takes over the tasks of the operator.

3.10.9. Experience

After May 2008 no waste facility should be allowed to operate without a permit and all waste facilities that are licensed are obliged to comply with *EU Directive 2006/21/EC*. Any waste facility that is granted a permit prior to the 2008 date has until 1st May 2012 to comply with the provisions set out in this *EU Directive*. This does not apply to waste facilities that have closed by May 2008.

4 DISCUSSION BASED ON CASE STUDIES

4.1. Legislation and Governance

The legal requirement for a mine closure plan or rehabilitation program may be found in either the mining law, as is the case in Ontario, Canada, or in both the mining and environmental laws which is more common. It is rarely found only in the environmental law. Some jurisdictions, such as Nevada, have developed a law solely to cover reclamation. Similarly the requirement for a financial surety is usually found in the mining and environmental laws or sometimes just in the mining law, though these usually do not identify the acceptable mechanisms.

As well as the relevant mining and environmental laws, most governments have produced regulations, guidelines or codes of practice that specify in more detail the requirements for rehabilitation and, in some cases, the financial surety mechanisms. For example, in Canada the Ontario Regulation 240/00 contains schedules that provide details of the rehabilitation requirements and information to be provided in the closure plan. The Government of Ontario has also produced a policy document that contains information on the type, and requirements for, each form of financial assurance accepted by the legislation. These are available on the Ministry of Northern Development and Mines website.

A number of countries included in the survey, such as Victoria, Botswana, Ghana and Sweden, are non-specific in regard to the size of a project that requires a financial surety. The legislation refers to the generic term 'mining' with the presumption that this encompasses all aspects including small, medium and large as well as exploration. In some jurisdictions smaller projects, alluvial mining and quarrying are treated separately. See table below.

Table 4.1.1: Summary of Mining Title specified in Legislation as requiring a Financial Surety

Jurisdiction	Prospecting	Exploration	Advanced Exploration	Mining (generic)	Other
Ontario			yes	yes	
Nevada		yes		yes	No financial surety for projects < 5 acres or producing < 36,500 t
Queensland				yes	Exploration and smaller projects are charged at a flat rate (see table p.21)
Victoria		yes		yes	Quarrying specified in separate legislation
Botswana				yes	
Ghana		yes		yes	
Papua New Guinea		yes		yes	Alluvial mining lease required to pay levy on sales
South Africa	Charged at flat rate			yes	
Sweden				yes	Quarrying specified in legislation
European Union					Waste management

In the majority of countries included in the survey the closure plan, rehabilitation and financial surety come under the jurisdiction of the government department responsible for mining or jointly with the department responsible for the environment. One notable exception to this is Queensland, Australia. In

1999 the government decided to transfer the responsibility for the environmental regulation and management of mining from the Department of Mines and Energy to the Environmental Protection Agency. This included transferring the responsibility for the rehabilitation program, though the receipt and management of the financial surety remained with the department responsible for mining. In most jurisdictions the department responsible for government finances is involved to some extent in the financial aspects of the implementation of mining legislation. This may involve full coordination in the receipt and administration of the financial surety, as is the case in Papua New Guinea, or only for tax purposes.

4.2. Financial Surety Instruments

Most of the regulatory authorities that responded to the survey allow a number of financial surety instruments to be used, with the notable exception of Victoria, Australia which will only accept a Letter of Credit (Bank Guarantee). The most common form of financial surety instrument currently in use is the Letter of Credit, which is accepted by all the developed countries included in the survey. Surety Bonds, Trusts Funds and Cash are used fairly regularly and Ontario and Nevada both allow Corporate Guarantees.

In some jurisdictions, for example Nevada, a combination of mechanisms is allowed for a single surety. This is most commonly used for larger companies that may obtain up to 75% of the financial surety as a Corporate Guarantee. Experience in some jurisdictions has shown that Corporate Guarantees do not provide sufficient protection, while in others Surety Bonds have failed to meet their expectations and Unit Levies have left governments with a shortfall when projects have closed prematurely. Cash financial sureties are more common for smaller mining companies which do not have sufficient assets to satisfy the requirements for a Letter of Credit. It is interesting to note that in Queensland the government will no longer accept a Corporate Guarantee because public opinion has no faith in them. The trend in developing countries is to use Trust Funds as the financial surety instrument of choice. These are also acceptable in Ontario and Nevada but are rarely used. In South Africa the major mining companies use centralized Trust Funds at a corporate level.

4.3. Timing

In most of the jurisdictions included in the survey the financial surety does not have to be lodged until after the mining title is granted. However, the legislation in all these cases does stipulate that no work is allowed to start on site until the financial surety is in place. In some instances, such as Victoria, Australia, the government issues a separate Work Authority after the surety has been arranged. In Queensland the financial surety for all mining titles, with the exception of a mining lease, have to be lodged before the title is granted. In this case the surety is required before activity starts on site. In Botswana the proposal is for the financial surety to be put in place before the mining title is granted.

All of the developed jurisdictions included in the survey, with the exception of Sweden which does not specify, allow for the financial surety to be funded in incremental payments. This was not stipulated in the legislation for the developing countries. However, the implication for South Africa is that the full amount of the financial surety must be in place before a project can start.

4.4. Scope of Financial Surety

In all the case studies included in this review the primary legislation (Act) is non-specific in terms of what should, or should not, be included in the financial surety. The scope is referred to in general terms such as ‘closure’ or ‘reclamation plan’, ‘rehabilitation’ or ‘revegetation’, with the detail being given in the secondary legislation (regulations, guidelines, codes etc). For example, in Ontario the Mining Act obliges the proponent to submit a closure plan which includes the financial surety. The detail of what is required in the closure plan, and thereby included in the financial surety, is specified in the Mine Rehabilitation Code. This provides the proponent with comprehensive guidelines and allows the regulatory authority to vary the requirements without having to change the primary legislation.

The financial surety is expected to cover the cost of all aspects of the physical closure of the site. In some jurisdictions this includes the administrative and management costs though these may be automatically included if the costs are based on the work being carried out by a third party. There is, however, considerable ambiguity surrounding the issue of the funding of long term care of the site, or what time period the financial surety should cover after the rehabilitation work has been completed. In Queensland this discrepancy was recently addressed by the introduction of residual risk payments. These allow for separate cash payments to be made, to cover future maintenance and reconstruction, when the Environmental Authority is surrendered or when progressive rehabilitation is certified.
If one project includes a number of different licenses or titles then most regulatory authorities only require one financial surety.

The IFC Environmental, Health, and Safety Guidelines for Mining (2007) specify that the mine closure plan should include socio-economic considerations and, by association, the financial surety. The only legislation that specifically includes the social and economic impacts in the mine closure plan is the Ok Tedi Closure and Decommissioning Code (see Chapter 3.7). The details of this requirement are stablished by Ok Tedi Mining Ltd, in consultation with the relevant stakeholders, and reviewed every two years. In Papua New Guinea, there is also a 'Future Generations Fund' that protects some minebenefits for use by subsequent generations. In addition, there is an infrastructure incentives scheme whereby, companies can use part of their income tax payments to construct infrastructure projects in agreement with the local community.

In the Philippines, a mine is required to contribute a percentage (90% of 1%) of the direct mining and milling costs to a centralized Social Development and Management Program (SDMP) as part of a five year plan. This program is designed to be used for the sustainable improvements in the living standards of the host and neighboring communities by creating responsible, self reliant and resource based communities. Details of the SDMP can be found on the Mines and Geosciences Bureau website (see Annex 1).

4.5. Level of Financial Surety

The level of financial surety can range from a few thousand dollars to hundreds of millions depending on the size, nature and complexity of the project. In most cases, the amount that is required for the financial surety is based on the specific itemized costs of all components included in the closure or rehabilitation plan. In some jurisdictions the detail is left up to the proponent, whilst in others the regulatory authority has established a list of the components and methods of calculation.

For example, in Queensland the Code of Environmental Compliance for Mining Lease Projects (available on the EPA website) contains a schedule of rehabilitation costs and specifies that maintenance and monitoring costs should be calculated at 10% of the total rehabilitation costs. Both Victoria and New South Wales use the URS/GSSE Rehabilitation Cost Estimate Tool (see Chapter 5.5). Since the introduction of the Tool in New South Wales surety funds have been increased by over 50%. South Africa has a similar method for establishing the financial surety contained in Section B of the Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine (available on the Department of Minerals and Energy website). The process, which is designed to be used by DME regional office personnel, involves ranking mines according to risk and the sensitivity of the area before applying unit rates for the various closure components. Up to 13% of this total may then be added for administrative and management costs and a 10% contingency.

It is common practice for the financial surety to include administrative and management costs, usually established on a percentage basis. The level of financial surety is commonly based on the work being carried out by a third party, such as an outside contractor. The only authority included in the survey that accepted the financial surety in the form of a Unit Levy is Ontario. This is established by looking at the proposed life of the mine, the estimated closure costs and the mining rate and then negotiating a dollar rate per tonne mined and the timing of the payments. The negotiations also establish that the financial
surety is covered by the half life of the mine. However, a number of jurisdictions do accept incremental payments, sometimes known as a Sinking Fund, for a number of financial surety instruments.

In Queensland the financial surety for exploration and small (standard) mining projects is based on the total area of disturbance and the risk associated with the rehabilitation (see Chapter 3.3). In 2008, the Western Australian Department of Industry and Resources published new rates for calculating environmental performance bonds (surety bond). These represent a minimum rate that will be varied according to the risk at a particular site. The minimum bond will generally be A$10,000.

Table 4.5.1: Western Australia Minimum Bond Rates 2008

Rate	Description	A$
1*	Tailings Storage Facilities, including in pit disposal, Heap/Vat leach, Evaporation dams, Turkey Nest Dams, Waste dumps, ROM pads, low grade oxide stockpiles, plant sites, workshops and process water dams	20,000
2	Camp Sites, Strip Mining (backfilled mining voids), hyper saline pipelines (>15,000 TDS), causeways, haul roads, sewage ponds and landfill.	5,000
3	Roads and access tracks, “Fresh” water pipelines, laydown areas, orrow pits and airstrips	3,000
4	Exploration – where clearing takes place, metal detecting, dry blowing and prospecting	2,000

** High risk facilities and landforms (sulphides present, highly erodible or >25m high) may attract ahigher rate and will be determined on a case by case basis).*

Large companies in Nevada may obtain a Company Guarantee, known as a State Corporate Guarantee, for up to 75% of the total financial surety if they can meet regulatory criteria to demonstrate adequate financial health. Similarly, in Queensland companies can earn a 75% discount based on previous environmental performance.

4.6. Tax Implications

The treatment of the financial surety for tax purposes varies from country to country. In Nevada, under both state and federal legislation, payments in to a financial surety are treated as an operating cost and therefore tax deductible, as well as the actual expenditure on rehabilitation. In addition, operators can distribute the rehabilitation obligation over a number of years thereby further reducing taxes. In contrast, in Ontario there is no tax allowance for a financial surety as the government does not consider it to be an expense as it will be returned to the company once rehabilitation has been completed. In Botswana, the industry is putting pressure on the government to make payments into a trust fund for afinancial surety, tax exempt.

4.7. Review

In all cases included in the survey the level of financial surety is established by the proponent and, in all but one, is reviewed by the relevant government department. The exception is Queensland where the proponent has to certify that the correct procedures have been used and the government has the power to impose severe penalties for providing false or misleading information. No authorities employ third party verification in the process of accepting the financial surety though, in Nevada, the public are allowed to review and comment. The legislation in all jurisdictions, apart from Ontario, allows for the financial surety to be reviewed and adjusted on a regular basis. The timing of this review varies from annual (South Africa) to every ten years (Queensland) depending on the size of the project, the lifespan or the liability risk. In Victoria, the draft Guidelines contain an assessment matrix forthe review period reproduces below.

Table 4.7.1: Victoria Surety Review Periods

Consequences	Likelihood			
	High	**Medium**	**Low**	**Negligible**
High	2 years Large mine - gold	3 years Large mine – other metals HM sand	6 years Large mine – non metallic (other than coal for major power generation)	10 years - Coal (major power generation
Medium	3 years Small mine – gold and other metals	6 years WA – regional significance	10 years WA – state significance	10 years
Low	6 years Small mine – non metallic	10 years WA – local significance	10 years	10 years

The majority of jurisdictions also require a financial surety to be reviewed and adjusted when the mining title in renewed, when there is a change to the operating plan, when there is a transfer of assets or when the regulatory authority has due reason to request a review. At the time of the review the level of financial surety can be increased or decreased. If the proponent is paying the financial surety in increments then the timing of reviews is usually more frequent.

4.8. Release

In none of the completed surveys were the funds available to the proponent for on-going rehabilitation during the life of the project. However, work that had been completed at the time of a review could be taken into consideration during the reassessment of the level of the financial surety. For example, in Nevada as discrete steps in the reclamation plan are completed partial release of the surety may be allowed.

Following the successful completion of rehabilitation most authorities, if they are satisfied no further claim might be made, return the majority of the funds held in the financial surety to the proponent. However, where necessary a number of jurisdictions withhold some of the funds for long term care costs. One variation on this theme is Queensland which can require a cash residual risk payment to be made when they release the original financial surety.

4.9. Additional Experience

Three of the case studies from developed countries reported that, when mines had closed due to economic difficulties, the financial surety had not been sufficient to cover the closure costs. In the developing countries the financial surety requirement had not been operating for long enough for there to be any examples or the y were reluctant to provide the information. The following examples are included to give an idea of how expensive closure legacies can be.

In the UK, following the coal mine closure program of the 1980/90's, the Coal Authority was left with substantial environmental and safety liabilities with no money to fund the required work. In the 2007/2008 tax year the Coal Authority spent £18.9 million managing legacy liabilities (£16.6 million 2006/2007), and currently has 46 operational water treatment schemes covering 300 kms of watercourses. There are a further 84 water treatment schemes that have been identified that need to be constructed by 2027 and it is estimated that the responsibility for mine water treatment will extend for another 100 years. According to the latest Annual Report, at the end of June 2007 the Western Australian Department of Industry and Resources held 3,365 unconditional performance bonds (suretybond) with a total value of A$608.3 million. This value represents approximately 25% of the expected total rehabilitation costs. In 2005 the amount held in bonds was A$430 million with an average of A$2,395/ha.

BHP Billiton's Island Copper Mine in British Columbia, Canada, closed in 1995. The closure plan submitted to the government in 1994 estimated the costs for environment mitigation and monitoring were C$15 million with additional money set aside for severance packages and decommissioning. It was presumed that monitoring would be required for 10 years with the level decreasing significantly for the second five years. Well in excess of these costs have now been spent. In 2007 it was reported that revegetation of the 700 hectares had been hugely successful and, over time, it is expected that the mine's closure objectives or productive forest and wildlife habitat will be achieved. However, since initialclosure, BHP Billiton has come to realize that the closed mine site will require care, maintenance and monitoring in perpetuity, principally due to the evolving nature of the mine drainage and its treatment requirements. For further detail see the 2007 Annual British Columbia Jake McDonald Mine Reclamation Award (www.trcr.bc.ca).

5 IMPLEMENTATION GUIDELINES

A financial surety is essential to ensure that an exploration or mining project does not burden a government with a detrimental environmental or social legacy. However, it should do more than protect the regulatory authority from the risk of default; it should also work as an incentive for the proponent to keep the physical impacts to a minimum and to carry out progressive rehabilitation. This incentive can be augmented by regular review and the release of the surety for work that has been completed. Site rehabilitation should be progressive so that, wherever possible, the rate of restoration is similar to the rate of exploration or exploitation.

Closure may not always occur as planned. The life span of an exploration project is dependent on the discoveries made, or not, and it is quite common for the life of a mine to be extended by the re-evaluation of existing reserves, changes in the commodity markets, new ore discoveries, etc. This type of change can be accommodated by revising the closure plan and reviewing and revising the financial surety. Alternatively, the life of an exploration or mining project may be curtailed unexpectedly because of falling metal prices, technical difficulties, or financial problems of the company. In these instances, if the company is not in a position financially to carry out any of the planned rehabilitation, it is essential that the regulatory authority has the funds available to commission the work themselves. Before setting up a financial surety it is essential to establish the rehabilitation goals. These should involve restoring all affected areas, as far as is possible, to their most appropriate economic and social value. This does not always involve returning a site to its original state or use. The main aims of site rehabilitation are to reduce the risk of pollution, to restore the land and landscape, to improve the aesthetics of the area and to prevent further degradation. These goals should be discussed as part of the consultation process and the views and opinions of the land owners and local community, as well as the national and provincial government, should be taken into consideration.

Site closure, especially in the case of a mining operation, can be difficult to define as a discrete period as post closure monitoring and long term care may be required after the rehabilitation work has been completed. The regulatory authority must take the necessary steps to ensure there will be sufficient funds available to pay for post closure monitoring and maintenance and, when required, remedial action. These funds can form part of the financial surety or a separate, self perpetuating fund, can be established when the original financial surety is released.

It is critical that the financial surety is only used for the purpose it was designed, and not viewed as a general source of funds by any of the parties involved. For this reason, it is advisable for the management and control of the fund to be shared by the regulatory authority and the company, with a clause allowing for the release of the fund if the company defaults. It is also essential that the financial surety is quarantined from other company assets, so that it cannot be seized in the event of bankruptcy, and from government abuse. The financial surety must be returned to the company following the satisfactory completion of mine closure and the rehabilitation program.

5.1. Legislation and Governance

The general direction is for legislation to be non-prescriptive, to allow for flexibility when regulating so as not to stifle development. In the case of financial surety, too much flexibility can result in confusion and inconsistencies, which may result in deterring investment. As can be seen from the survey carried out for this report, there are as many variations in the way financial surety requirements are included in the legislation, and administered by the regulating authority, as there are case studies. The simple education is that there is no 'correct' way of legislating for, or managing, financial surety requirements. However, if a system is too complex neither the industry nor the government will implement it successfully. Legislation should also be designed to take government structure and capacity into consideration.

It seems that it works better to have an independent mine closure law that establishes asingle agency to implement the law. This model gives the business community anassurance that one agency will take the lead on its problems and that it will not have toanswer to many differing opinions on how operation, reclamation and closure successwill be measured. This model also allows the public and NGOs a single place to go forinformation on mining regulation.
Ref: Cochilco, MMSD 2002

At present, any mining project whether exploration or exploitation, in almost any country, has to obtain a mining (or exploration) license and an environmental permit. These requirements are contained in the Mining Act and the Environmental Act which are usually administered separately, by the relevant department. Prior to obtaining an environmental permit, most jurisdictions require the proponent to produce an environmental impact assessment that would also contain a closure or rehabilitation plan. It is therefore logical to assume that the financial surety requirement for rehabilitation would be included in the environmental legislation and administered by the relevant department. In practice however, this logic does not stand up to scrutiny. Many or most of the environmental liabilities associated with mining are now an accepted integral part of the overall operation and closure plans are as much part of the operating plan as they are of the environmental assessment. In addition, it is common practice for the mining legislation to include most, if not all, of the financial aspects of the license. For these reasons it makes more sense for the financial surety requirement to be a part of the mining legislation and to come under the authority of the department responsible for mining. That said, it is essential that the administration and management of the financial surety should involve consultation with all relevant departments including environment, water and finance.

Recommendations:

- A financial surety should be a requirement for all projects but tailored to fit the size and complexity of the project.
- The financial surety requirement should be clearly stated in the legislation and should be linked to the permitting process.
- The legislative, regulatory and fiscal framework for financial surety should be clear and application consistent.
- The financial surety requirement should be primarily included in the mining legislation, preferably directly associated with mine closure.
- The law or act should be supported by regulations and/or guidelines that specify the rehabilitation requirements and financial surety mechanisms.
- The department responsible for mining should administer the financial surety in consultation with other relevant departments.

5.2. Financial Surety Instruments

Success of any financial surety instrument depends on the care and effort put into setting it up and managing it. Most will work if they are done properly. The most commonly used forms of financial surety are the Letter of Credit, Surety Bonds, Trusts Funds and Cash.

A *Letter of Credit*(Bank Guarantee) is the most frequently used type of financial surety instrument. These are acceptable to the industry because they are relatively cheap to set up and they are attractive to governments because there are less administrative requirements. However, obtaining a Letter of Credit may reduce the borrowing power of the company.

Surety Bonds have many similar attributes to the Letter of Credit and are attractive to smaller companies as they do not involve tying up capital. However, the long term viability of the insurance company providing the bond should be taken into consideration.

Trust Funds are more visible and often better understood than other forms of financial surety. Any surpluses created in the fund can be returned to the proponent with more ease but, if they are invested, there is the possibility that the value of the fund will fall. It can be difficult to ensure that their value stays in line with the rehabilitation obligations. Trust Funds are more available to smaller mining companies which do not have sufficient assets to satisfy the requirements for a Letter of Credit or Surety Bond.

Cash also provides a more attractive option for smaller companies (see Trust Fund) and the money can earn interest and thereby keep ahead of inflation. There are no delays in getting access to the money and no need to retrieve the entire fund if only part is required. Cash is also easier to place in a pooled fund. However, a Cash fund may be more accessible to misappropriation. There is also the risk that, should the mining company become bankrupt, any cash deposits will be recovered by the receiver.

The *Company Guarantee* is the financial instrument of choice of the mining companies due to the lack of cost and paper work involved. However, they do tend to fail because the time when the money is most needed is often when the company is not able to deliver. They are also unpopular with the public which does not hold the mining industry in very high regard and therefore does not trust this form of financial surety. This type of financial surety instrument is only really acceptable for large, well established companies and can therefore be seen as being a disadvantage to smaller operations.

Insurance Schemes are currently not available to the mining industry outside of the USA.

Unit Levy and *Pledge of Assets* are increasingly unlikely to be accepted as financial surety instruments because of the uncertainty of the fund meeting the rehabilitation requirements.

A *Fund Pool* and *Transfer of Liability* are not widely available and generally not recommended.

The choice of financial surety instrument will depend on the track record and financial strength of the proponent, the level of surety required and the period of time it is necessary. It is essential that the financial surety can be converted into cash quickly and reliably and can only be used for the purpose for which it was designed. It is also essential that the financial surety is quarantined from other company assets, so that it cannot be seized in the event of bankruptcy, and from government abuse. In some instances a combination of financial surety instruments may prove to provide the best cover.

Recommendations:

- Produce guidelines identifying which forms of financial surety are acceptable and how they should be implemented.
- Allow the proponents a choice of fund, preferably from the first four in the above list.
- Ensure that unbiased financial advice is available in the choice of the financial surety and its management.

- Ensure that the financial surety is quarantined from other company assets, so that it cannot be seized in the event of bankruptcy, and from government abuse.
- Ensure the financial surety can only be used for the purpose for which it was designed and in a timely fashion.

5.3. Timing

The financial surety can be put in place either before the mining title is granted or after the mining title is granted but before the proponent is allowed to start work on the site. There are no benefits or disadvantages for either option as long as the security is lodged before any work starts on the site that would require rehabilitation. The incremental payment of a financial surety may be an acceptable option, especially in the case of a large project with a long life span. However, it should not be the preferred option for explorations sites or smaller projects.

Recommendations:

- The financial surety must be in place before work starts on the site.
- If the financial surety is to be paid incrementally, ensure the funds are always sufficient to cover closure costs.

5.4. Scope of Financial Surety

The scope of the financial surety is currently accepted to include all the physical aspects of mine closure. This should include activities associated with decommissioning, removal of plant and infrastructure, as well as rehabilitation. The main question is how prescriptive the administrative authority needs to be in defining all the elements. While some jurisdictions feel it is necessary to provide proponents with detailed lists of the specific elements to be included in the financial surety, others hardly provide any guidance at all. A balance between these two might be the seen as the best option.

It is essential that the mine closure and site rehabilitation goals are an integral part of the scope of the financial surety. These can be established as closure criteria or standards and should take into consideration the potential end use for the site. Almost all sites, especially mining licenses, will require some form of post closure monitoring and, in some cases, long term care and/or remedial action. These requirements should be included in the financial surety scope.

The social and economic aspects of mine closure, and financial implications, are discussed in separately (see Chapter 5.9) and are not included in the following recommendations.

Recommendations:

- Establish the physical mine closure and rehabilitation criteria or standards.
- Establish outline guidelines of the elements of mine closure and rehabilitation to be included in the financial surety.
- Consult with the relevant environmental authorities to ensure all aspects of the environmental assessment are addressed.
- Consult with the community regarding rehabilitation goals and end of site use.
- Set up procedures for establishing the requirements for long term maintenance and monitoring and the method of funding.

5.5. Level of Financial Surety

For exploration sites and small, low risk mining projects it is feasible to use a basic formula to calculate the required level of financial surety. For the larger, high risk mines it is advisable to establish a detailed breakdown of all the components with individual costing. The level of financial surety is usually worked out by the proponent and then submitted to the regulating authority for review. Often, in the case of international companies, the person calculating the figures is not in their home country, and therefore not in a position to know what the various costs will be. Because of the specialized nature of the work the costs can be difficult to come by. Establishing accurate rehabilitation costs is not an exact scienceand this just adds another level of uncertainty.

The level of financial surety can be calculated in a number of different ways:

- Use of a formula based on the type of project, rehabilitation plan and/or track record of the company.
- Specified in legislation on standard rates and unit costs.
- A percentage of capital costs.
- Negotiated based on the feasibility study.
- Negotiated on a per tonne basis.

Whichever method of establishing a financial surety is chosen, the details should be worked out on a site by site basis and any guidelines or models just used as a starting point. A more complex rehabilitation Cost Estimate Tool (see Box 5.5.1) has been developed in Australia which may help to remove some discrepancies across the industry and the need for detailed review by the government. This Tool should also ensure that the level of financial surety is not dependent on the business success of the company or the overall economic conditions in the mining industry. In Australia all mines in New South Wales, and more complex minesin Victoria, are required to use the Tool to assist in surety calculations.

Another Cost Estimation Model for Mine Closure has also been developed for a Ph.D. dissertation at Colorado University (Peralta-Romero 2007). This Model uses the graphical interface of MS Excel with three main functional modules; input and utilities; closure activity costs; and output, with color differentiation. Information contained in a database can be incorporated into calculation worksheets including disturbance rates, equipment type and model, production rates and unit costs. The model will then generate an executive cost summary.

The financial surety should be designed to cover all mine closure costs at the time of closure, whether planned or not, in the absence of the proponent. This means that, at a minimum, the amount should be based on third party costs and should include all administrative, maintenance and monitoring costs. There are also good arguments for the inclusion of a contingency, allowance for engineering redesign and inflation. The required standard of rehabilitation is site specific and this should be reflected in the financial surety calculations.

Junior and local mining companies may not have the necessary financial resources to establish the entire surety before the start of a project. Paying the financial surety in increments may be the only alternative. However, there is always a risk with incremental contributions that, at any given time, the surety may not be sufficient to cover the costs of rehabilitation should the proponent default. Most junior companies use outside financing so it may be possible for the financial institution involved to also provide a Bank Guarantee. Alternatively, the company could reduce the initial operating plan size so that both capital costs and the financial surety are less.

Recommendations:

- ➢ Establish guidelines containing an outline of rehabilitation costs.

- Ensure these costs are based on using a third party contractor, include all administrative costs, a contingency and inflation factor.
- Use site specific costs based on site specific closure plans.
- Include a separate cost item in the financial surety for remedial action, maintenance and monitoring.
- Accept incremental payments of the financial surety as the last option.

5.6. Tax Implications

There are five separate issues related to tax and a financial surety fund. These are:

1. Whether money paid into the financial surety is counted as an operating cost or an expense and is therefore tax deductible?
2. Whether decommissioning and rehabilitation costs count as an operating cost and are therefore tax deductible?
3. Is any interest earned on the financial surety fund taxable?
4. Is any capital gain made on the financial surety fund taxable?
5. When the financial surety fund is released back to the company is it taxable?

Box 5.5.1: Rehabilitation Cost Estimate Tool

Two consulting companies in Australia, URS and GSSE, have developed a RehabilitationCost Estimate Tool. This is a cost calculation workbook, using Microsoft Excel, that aimsto provide mine operators or government with a general guide in calculating anappropriate rehabilitation estimate.

The design of the workbook is a tiered approach which establishes the level of detailrequired based on the scale and type of operation. The mine site is divided into a series ofdomains, each representing a unique area, and comprising a number of precincts. Byselecting the type of mining operation the relevant domain worksheets will be activated.

The Tool includes all aspects of mine closure from the demolition and removal of infrastructure to the maintenance and monitoring of the rehabilitation. Third party costs,as well as administration and management, are also built in to the workbook. The unitcosts used in the Tool are based on generic rates though there is the facility for users toinsert their own rates, with justification. The costs do not incorporate an automaticcalculation to determine future value.

Comments from the industry say that the Tool is easy to use, provides a useful frameworkfor developing the closure plan and has a clear systemic approach. However, theintegrated costs in the Tool do not take account of regional variations. In addition, it hasbeen reported that there has been a substantial increase in rehabilitation cost estimatessince the introduction of the Tool.

For further information contact michael_woolley@urscorp.com.

One question is, if the funds paid into a financial surety are tax deductible, then the decommissioning and rehabilitation costs should not be, or vice versa. However, there is a problem making decommissioning and rehabilitation costs tax deductible because the majority of the expenditure comes once a mine has ceased operating and so there is no income to offset the tax against. One way of getting round this problem is to allow a company to claim tax deductions for closure provisions based on a unit of production basis during the operating life of the project.

The countries that took part in this survey generally accepted that the administration costs associated with setting up and managing a financial surety are tax deductible as a business expense. It is also acknowledged that any interest earned by the financial surety, or capital gains made by the fund, are taxable but that the release of the original fund is not. For obvious reasons, the mining industry will wish to secure as many tax breaks as feasible and the onus is on the government to establish a fair system that takes into consideration the financial implications for the industry. As can be seen from the case studies, attitudes do vary around the world to this sensitive subject. In spite of some individual attitudes, there can be no wrong or right way of making these decisions, just the best for the countryinvolved.

Recommendations:

- Liaise with the department responsible for government finances before making any decisions.
- Liaise with the mining industry as to the implications for different tax regimes before establishing the requirements.
- Establish the tax regime and stick to it – avoid negotiation on a site by site basis.

5.7. Review

When the financial surety is submitted to the regulatory authority it is usually reviewed internally. This process is complex, uses considerable resources and can be very time consuming as it involves negotiations and consultations. If the relevant department does not have the capacity to carry out the review internally then third party verification could be considered. This could either be done by the proponent, with a system of certification, or by the regulatory authority. The financial surety arrangements should also be part of the community consultation process so that the end use for the site can be established. Ideally this should take place at the same time as the environmental and social impact assessment consultations and should include the mine closure and rehabilitation plan.

During the life of the project the closure and rehabilitation requirements may change due to planned or unforeseen modifications to the exploration or operating plan. This means that there needs to be a mechanism for reviewing and adjusting the financial surety. There should also be a statutory requirement for periodic reviews of the financial surety to enable the regulators to ensure that the surety level is adequate and that the fund is properly secured. The period between reviews depends on length of project. The World Bank Report (2002) recommends every 5 years for a 30 year project life and every 2 years for a 10 year project life. The IFC Guidelines (2007) state that the mine closure requirements should be reviewed on an annual basis and the closure funding arrangements adjusted to

The review would be carried out by the proponent and submitted to the regulatory authority. The same verification and consultation process should then be repeated as for the initial submission. At the time of this review any rehabilitation carried out by the proponent could be taken into consideration in re-establishing the level of financial surety. However, the adequacy of the rehabilitation work must be assessed before any reduction in the financial surety is accepted.

Recommendations:

- Establish whether the initial assessment of the financial surety will be carried out by the regulatory authority, by the proponent, or third party verification.
- Establish the consultation process.
- Establish requirements and processes for periodic reviews.

5.8. Release

The financial surety fund should not be available to the proponent to pay for on-going rehabilitation. However, if rehabilitation has been carried out it could be taken into consideration at the time of the periodic reviews. Staged reductions in the level of financial surety can help to promote progressive rehabilitation and good practice.

Following the satisfactory completion of mine closure and the rehabilitation program, the financial surety fund can be returned to the proponent. Before any money is returned the regulatory authority should establish that the program has been successful and no further work is required on the site. A commonly used method of evaluating the release of the financial surety is the success of the revegetation program. It is also possible to use the surface stability or water quality, or a combination of all three.

If the site requires long term monitoring, maintenance and/or remedial action, a separate fund should be set up to finance this for whatever period is required. This fund should be self perpetuating so that the regulatory authority is never left with a deficit.

Recommendations:

- Establish practical criteria for assessing adequacy of rehabilitation efforts (completion criteria).
- Establish criteria for the release of a financial surety including staged reductions during the operating life of the project.
- Establish a method of funding long term monitoring, maintenance and remedial action.

5.9. Social and Economic

It is starting to be accepted that it is essential to set funds aside early on in project development to finance the social and economic aspects of mine closure. Severe economic distress may follow closure if the project is the sole source of direct and indirect employment in the region and unsustainable social infrastructure that was previously supported by the mine is liable to collapse. The elements that should be taken into consideration are:

- Redundancy payments
- Retraining schemes
- Support for dependent (spin-off) businessesUtilities: electricity, water, communications etc
- Social facilities: health, education, justice etc
- Infrastructure: roads, airstrip, wharf etc
- Food security
- Financial system

At present, it is not common for financial provisions to be made for these aspects of mine closure though there are some notable examples such as Papua New Guinea and the Philippines (see Chapter 4.4).

Integrated closure planning should, as the name suggests, include all aspects of mine closure and, by association, the financial implications of the social and economic impacts should also be taken into consideration. However, the nature of the requirements is very different to the physical financial surety and there may be advantages in keeping the funds separate. This can be achieved by establishing a specialized trust fund or foundation that is designed to exist for a period of time after mine closure.

6 AFTER THOUGHTS

The most memorable statement that has been made during the research and consultation that went in to producing this report is the following:

"I have never seen a closure program cost less than the estimate."

Even with the best will in the world, forecasting accurate estimates for closure costs is extremely difficult and the best that might be expected is a close approximation to the reality. The temptation could be to over estimate, in order to ensure that there is not a shortfall in funds, but this should not be done to the detriment of the financial viability of the industry.

In 1999, a principal environmental specialist with the European Bank for Reconstruction and Development identified a number of specific risks and suggested mitigation related to financial sureties. These are presented in Box 6.1. All these risks are still relevant today and need to be taken into consideration when establishing the policy and regulatory framework for the implementation of financial sureties.

Both the regulatory authority and the mining companies have a vested interest in agreeing on a realistic level of financial surety. The government needs to ensure that there are sufficient funds to complete a satisfactory rehabilitation program but at the same time maintain an attractive investment climate. The mining company has to have adequate capital to continue with the investment.

The required level of financial surety can be a substantial portion of the capital costs of the project and junior and local mining companies may not have the financial resources to provide the funds up front. In this instance, the government has to decide whether or not they want to take the risk of these companies defaulting on their obligations. The requirement for an up front commitment to the full amount of the financial surety is one way of testing the commitment and resolve of the company. It should also work as an incentive for the proponent to keep the physical impacts to a minimum and to carry out progressive rehabilitation.

There is also a risk associated with the financial surety instruments. The long-term viability of the bank or company providing a Letter of Credit or Surety Bond cannot be guaranteed. In Australia, a company that provided Surety Bonds to the mining industry collapsed and the bonds were rendered worthless. Additionally, if a mining company goes bankrupt, a financial surety that is not isolated may be frozen or claimed to pay creditors. There is also a risk that any form of cash investment might be seen as too much of a temptation for someone with corrupt tendencies.

In spite of all the pitfalls, financial sureties are essential in ensuring that that the physical impacts of mining are minimized in the short term and non-existent in the long term.

Box 6.1: Specific Risks and Suggested Mitigation

Premature termination during construction: Project termination for technical or financial reasons can be mitigated with adequate completion guarantees which ensure that premature termination and abandonment will trigger an obligation by the guarantor to implement, or cause and fund a third party to implement, a satisfactory closure program.

Material changes made to closure requirements and objectives: During the mine life material changes can largely be avoided by agreeing a clear, transparent, up-front, realistic and approved definition of post-operational land use, the environmental performance standards to be met within a specified period of time, and sign-off procedures to be followed.

Material changes to the project and processes: These changes may have implications with regard to mine closure requirements and related costs. Mine closure plans, the related costs implications and financial guarantees should be subject to a periodic review process, so that the implication of any material change can be assessed and addressed; This would also mitigate the risk of significant over- or under-capitalization of the closure funds and related guarantees which should reflect the life of the mining project based on proven reserve estimates.

The risk of financial failure: Financial failure of the mining company and organizations involved in the financial guarantee (holder of cash reserve, trust fund, etc.) resulting in a failure to provide funding for mine closure can be mitigated by establishing non-accounting provisions monitoring financial performance, separating the financial structure for the closure fund from that of the company, allowing only investments of closure funds in financial instruments providing ‘assured’ future payment, and spreading the risk to a combination of financial vehicles to jointly secure closure funds.

The danger of closure funds being redirected: This can be mitigated by using a non-fungible financial structure and a certification process, for example involving a trustee, for appropriate use of proceeds to safeguard closure funds from being used, for payment for measures unrelated to the project such as additional drilling, or repayment of loans in a default situation.

The government might continue operating an ‘inherited’ project: This could occur without due consideration given to profitability and environmental implications which would have otherwise required implementation of mine closure activities. Experience seems to suggest that funding limitations may ‘discourage’ the government to implement mine closure in the absence ofavailability of funds earmarked for this purpose.

Ref: Nazari 1999

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ANNEX H-1 WEB SITES

Australia
NSW – Department of Primary Industries www.dpi.nsw.gov.au
Queensland – Environmental Protection Agency www.epa.qld.gov.au
Queensland – Department of Mines and Energy www.dme.qld.gov.au
Victoria – Department of Primary Industries www.dpi.vic.gov.au
Victoria – Department of Sustainability and Environment www.dse.vic.gov.au
Victoria – Legislation www.dms.dpc.vic.gov.au
State – Department of Industry, Tourism and Resources www.industry.gov.au
Best Practice Environmental Management in Mining Booklets
www.natural-resources.org/minerals
Minerals Council of Australia www.minerals.org.au
Western Australia – Department of Industry and Resources www.doir.wa.gov.au
Botswana
Department of Mines www.mines.gov.bw
Department of Environmental Affairs www.envirobotswana.gov.bw
Canada
Legislation – Mining Law and Regulations www.e-laws.gov.on.ca
Ontario Ministry of Northern Development and Mines www.mndm.gov.on.ca
Ontario Mineral Exploration and Mining www.serviceontario.ca/mining
European Union
European Commission – DG Environment www.ec.europa.ec/environment
EU Database www.europa.eu.int/eur-lex
Ghana
Ghana Minerals Commission www.ghanamining.org
Ghana Environmental Protection Agency www.epa.gov.gh
Papua New Guinea
Department of Mining www.mineral.gov.pg
Mineral Resources Authority www.mra.gov.pg
Government Departments www.pngonline.gov.pg/government
SASSOON 2008 WORLD BANK
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Ok Tedi Mining Ltd www.oktedi.com
Philippines
Department of Environment and Natural Resources
Mines and Geoscience Bureau www.mgb.gov.ph
South Africa
Department of Minerals and Energy www.dme.gov.za
Department of Environmental Affairs and Tourism www.environment.gov.za
Sweden
Swedish Government www.sweden.gov.se
Mining Inspectorate www.bergsstaten.se
Environmental Protection Agency www.naturvardsverket.se
USA
Nevada Bureau of Land Management www.nv.blm.gov
Nevada Division of Environmental Protection www.ndep.nv.gov
Nevada Commission of Mineral Resources www.minerals.state.nv.us
Nevada Legislation www.leg.state.nv.us

Nevada Standardized Reclamation Estimator Model www.nvbond.org
US Forest Service www.fs.fed.us/geology

Odds

International Council on Mining and Metals www.icmm.com
International Institute for Environment and Development/MMSD www.iied.org/mmsd
Centre for Science in Public Participation www.csp2.org
The World Bank www.worldbank.org/mining
Department for Communities and Local Government www.communities.gov.uk
(Proceedings of Seminar On Financial Guarantees)

ANNEX H-2 LETTER OF CREDIT TEMPLATE

DRAFT FORM OF IRREVOCABLE LETTER OF CREDIT

(To be typed on Bank Letterhead)
Her Majesty the Queen in Right of Ontario as represented by
The Minister of Northern Development and Mines
Ministry of Northern Development and Mines
933 Ramsey Lake Road
6th Floor
Sudbury, Ontario
P3E 6B5

We hereby issue in your favor this Irrevocable Standby Letter of Credit in the amount of <X SUMOF DOLLARS (CAD $X)>, which is available by payment against your written demand, addressedto <BANK X, ADDRESS>, bearing the clause "drawn under standby letter of credit Number...issued by <BANK X, ADDRESS>."

Any written demand for payment must be accompanied by your signed certificate stating that theMinistry of Northern Development and Mines has the right to make demand for payment inaccordance with a closure plan between <PROPONENT Z> and the Ministry of NorthernDevelopment & Mines regarding closure costs for the <ABC MINE/SITE/LOCATION>. We shallthen honor your demand without enquiring whether you have the right as between you and ourCustomer, <PROPONENT Z> to make such demand and without acknowledging any claim of ourCustomer.

This Letter of Credit will continue to <DATE, 200x> and will expire on that date and you may callfor payment of the full outstanding amount under this Letter of Credit at any time up to the close ofbusiness on that date. It is a condition of this Letter of Credit that it shall be deemed to beautomatically extended for one year from the present or any future expiration date hereof, unless atleast ninety (90) days prior to any such date, we shall notify you in writing by Registered Mail thatwe elect not to consider this Letter of Credit renewed for any such additional period. In the event ofa notification of non-renewal, the Ministry may demand the full or any portion of this creditprovided the customer has not provided the Ministry with full alternate financial assurancesatisfactory to the Ministry at least 10 days prior to the expiration of this Letter of Credit.

It is understood that the amount of this credit may be reduced from time to time as <PROPONENTZ's> obligations pursuant to the aforementioned Agreement are discharged, such reduction will beeffected upon receipt of your written notice delivered to this office.

Written demands for the full amount or any portion or portions thereof must be presented to usalong with this original Credit Instrument.

This Letter of Credit is subject to the "Uniform Customs and Practice of Documentary Credits(1993 Revision) International Chamber of Commerce, Publication Number 500."

ANNEX H-3 SURETY BOND TEMPLATE

LAND REHABILITATION PERFORMANCE BOND

Bond # Amount:

KNOW ALL PERSONS by these presents that [*name of compan*y] (hereinafter called the Principal) whose place of business is at [company address] and The [name of insurance company] (hereinafter called the Surety) whose place of business is at [insurance company address] are held and firmly bound unto Her Majesty the Queen in Right of Ontario as represented by the Minister of Northern Development and Mines, its heirs, and successors (hereinafter called the Obligee) whose place of business is at B6 - 933 Ramsey Lake Road, Sudbury, Ontario P3E 6B5 in the penal sum of [*amount of bond*] lawful money of Canada for the payment of which we bind ourselves, our heirs, administrators and successors, and assigns firmly by these presents.

WHEREAS, the Principal will operate/operates a [*mining activity*] located at [*legal property description*] (locally known as _____________) in accordance with a certified Closure Plan filed with the Director of Mine Rehabilitation on _______________.

NOW, THEREFORE, the condition of this obligation is such that, if the Principal shall comply with the terms of the certified Closure Plan then this obligation shall be void; otherwise it shall remain in full force and effect, subject to the following conditions:

1. Whenever the Principal shall be in default and declared by the Obligee to be in default of the terms of the certified Closure Plan, the Obligee shall send a registered letter to both the Principal and Surety, stating in substantial detail the facts leading to the default.
2. That the Surety's obligation to the Obligee shall only be to pay such amounts demanded by the Obligee and this bond will be totally exonerated by remitting to the Obligee such amounts in default, provided however, the total liability of the Surety shall in no event exceed the penal sum of the Surety.
3. The term of this bond shall remain in full force and effect to the time of release of the bond by the Ministry of Northern Development and Mines, or replaced by a form of financial assurance acceptable to the Director of Mine Rehabilitation.
4. Provided that, if the Surety at any time gives at least three calendar months notice in writing to the Obligee and to the Principal of its intention to terminate this obligation, then this obligation shall be deemed to be terminated on the date stated in the notice, which date shall not be less than three calendar months after the date of the receipt of the notice by the said Obligee or by the said Principal, whichever is the later date of receipt, provided that, should the Principal fail, within two calendar months of the above referred to later date of receipt, to provide a financial assurance in at least the same amount as this bond in a form acceptable to the Obligee, the Surety shall automatically and immediately pay the full amount of the bond to the Obligee.
5. Any suit or action on this bond against the Surety must be commenced by the Obligee within 120 days from the date of notice of default mentioned in clause #1 above.
6. In the event the Surety becomes unable to fulfill its obligations under the bond for any reason, notice shall be given immediately, by registered mail, to the Principal and the Obligee. Upon Obligee's receipt of Surety's notification or upon the incapacity of the Surety by reason of bankruptcy, insolvency, or suspension or revocation of its license, the Principal shall be deemed to be without bond coverage and will be required to submit alternate financial assurance, subject to the approval of the Obligee and as required by Section 145 of the Mining Act, within 30 days.
7. The Surety is approved under the Insurance Act or its successor.

8. Upon partial completion of the rehabilitation and reclamation of the site, and the submission by the Principal of a written application under Section 145 of the Mining Act including technical supports and relevant information, the Director of Mine Rehabilitation at his discretion may reduce the amount of the bond to an amount consistent with the financial requirements of the rehabilitation work left to be completed.
9. This bond will be valid for the term of [*date bond sealed*] to [*date 1 year hence*] and shall be automatically renewed, without further documentation from year to year thereafter unless terminated as aforesaid, provided that the Surety may, if it wishes, issue certificates evidencing such renewal.

Sealed with the respective seals of the Principal and of the Surety the ____day of
_________, 20 .

SEALED, SIGNED AND DELIVERED [NAME OF COMPANY]
In the presence of

____
_________________________________ Signature

____
Name of Signatory (Please Print)
[NAME OF SURETY]

____
Signature

____
Name of Signatory (Please Print)