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Main Report

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Preface

The Large Volume Waste (LVW) study was one of many projects completed by the Mining, Minerals and Sustainable Development (MMSD) project. Large volume waste disposal and its effects on the environment and society were identified early in the project as a matter of specific concern.

A large number of people contributed to the success of this project - Project Manager, Dirk van Zyl, (Director of the Mining Life-Cycle Center, Mackay School of Mines, University of Nevada, Reno), Caroline Digby (MMSD Research Manager) and Anne-Marie Fleury and Silvia Kyeyune (MMSD Research Fellows). The latter two undertook most of the information and report compilation. The work was carried out between August 2000 and April 2002.

An independent review process was established in September 2000. Meredith Sassoon (an independent UK-based private consultant on Environmental Management of Mining) was appointed as Chair of the Review Committee (RC). The RC had 27 members representing industry, government, NGOs, community and other perspectives (their names and affiliations are listed on the page following this Preface). A smaller group of 6 were invited to comment on the drafts of all documents, while the entire RC were invited to review all final drafts. The following process was followed. Once the work group completed the drafts of documents, they were reviewed by the chair of the RC before being sent out to the RC for review. After receiving the multiple comments the RC chair incorporated these into the drafts. It is clear from this that Meredith Sassoon, the RC chair, did a large amount of work to make these documents readable and to incorporate the many comments. The RC provided all their review time free of charge and their input made many improvements to the original drafts.

The following sequence was followed in the preparation of these documents:

- Concept papers were prepared and reviewed in late 2000 which were used as guidance in preparing the first drafts of the working papers;
- The Large Volume Waste, Mine Closure and Abandoned Mines Working Papers (Appendices A, B and C) were prepared and reviewed during the first half of 2001;
- A workshop held in Vancouver, Canada, from July 15-17th 2001, provided a broader forum of input on the Large Volume Waste issues. The 65 attendees to the workshop included the work group, RC and others (see the end of the Workshop Report, Appendix E, for a list of attendees). The Workshop Report was prepared by the RC chair and reviewed by attendees to the workshop;
- Further comments were received and information developed following the workshop. Most of the work group plus a few others from the RC got together in March 2002 to develop the main report and do final editing of the working papers. Afterwards, final review comments were invited on all these documents.

This final document of the Large Volume Waste Project includes the main report, three working papers (Appendices A, B and C) and the Workshop Summary and

Recommendations (Appendix D), and the Workshop Report (Appendix E) . When the project started three specific issues came to the forefront: tailings storage facility failures, acid drainage and riverine disposal. The papers completed on these topics are found in Appendices F and G. The contribution of a paper especially prepared for this volume by Todd Martin and others of AMEC Earth and Environmental and AMEC Simons in Vancouver, Canada on Stewardship of Tailings Facilities is highly appreciated. Many thanks also to Kim Lapakko of the State of Minnesota for allowing us to reprint his document on acid drainage characterization. Finally, three case studies on the active riverine disposal projects were prepared and are included (Appendices H, I and J).

Many people gave generously of their time in developing these documents, thank you very much. My special thanks to MMSD - Project Director Luke Danielson for making it possible for me to participate in this project, Caroline Digby and the rest of the London staff. A special word of thanks to Meredith Sassoon who put in long hours to make these documents readable and to include the comments received during the process.

My special thanks to Dean Jane Long of the Mackay School of Mines at the University of Nevada, Reno for agreeing to my participation and in kind contribution of a large part of my time. The Mackay School of Mines was a co-sponsor of the MMSD as a result of this contribution.

One specific lesson learned in this process was that it would have helped to make the process more efficient if we had a small focused workshop early on in the project with a range of stakeholders to develop a detailed scope.

Everything that went well is thanks to the great team, I accept responsibility for those things that do not work well in these documents.

Dirk van Zyl
Reno, April 2002

Large Volume Waste Project Review Committee

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1 Introduction

The classic definition of sustainable development, as stated by the Brundtland Commission, is to meet the needs of the present generation without undermining the capacity of future generations to meet their needs. From this it is possible to derive five distinct principles that help to implement the concept. These are:

- material and other needs for a better quality of life have to be fulfilled;
- for people of this generation;
- as equitably as possible;
- while respecting ecosystem limits; and
- building the basis on which future generations can meet their own needs.

The core principle of sustainable development is improving human well-being and the environment and sustaining those improvements over time. It means passing the requirements of survival on to future generations and bequeathing roughly the same, or an increased, total stock of capital. Capital lies at the heart of any debate on sustainable development and can take five main forms: natural capital, manufactured capital, human capital, social capital and financial capital. Whether we are on the path of sustainable development is measured by the net gain or loss in all of these capital stocks over time.

Many people hold the view that natural capital should not be used at a rate that exceeds the capacity for replenishment or that reduces environmental quality, regardless of whether in the process other capital stocks are increased. Others believe that when natural capital is reduced, the conditions for sustainable development may still be met so long as other forms of capital, such as manufactured and human capital, increase. This debate over 'hard' and 'soft' views of sustainable development is discussed in more detail in Chapter 1 of the MMSD Final Report, *Breaking New Ground*.

Many of the decisions relating to mining have the potential for impacting any of these forms of capital. In particular, it is hard to say that a mining project is building natural capital. Decisions made by past generations have clearly impaired the natural capital we have inherited. While dramatic strides in reducing impacts have been made, the overall impact of the industry is still in the negative column. But it is not impossible to imagine how the industry could come closer to balancing the natural capital account. The three steps to balancing the natural capital account with respect to large volume waste, mine closure and abandoned mines are:

- Minimise the negative impacts of the disposal of large volume waste;
- Where possible, increase the environmental, social and economic benefits of mining projects; and,
- Rehabilitate abandoned mines at a sufficient rate that the net effect is positive.

All mining operations generate waste.[1] Mineral deposits can be thought of as natural pre-concentrations of materials that, by virtue of their unique properties and the uses to which they can be put, go to building manufactured capital. Mining, mineral processing, leaching, smelting and refining are the additional stages necessary to produce the mineral related commodity in its usable form. At each of these stages the rejects are wastes and, because economic mineral deposits can contain low or very low concentrations of the valuable constituents, these are produced in large volumes. Table 1 presents some examples of the percentages of material that is extracted that ends up as waste for selected metals.

One of the widespread management problems in the mining industry relates to the sheer volume (as well as the chemical composition) of waste material handled. These very high volumes mean that where it is put and how it is managed are critical to determining the impact of mining. Because wastes may occupy large areas of land, how they are managed and whether the areas they cover can be returned to a beneficial use post-mining are very important to local economies. And because it is very expensive to move them, how they are handled is also critical to the economics of mining operations.

The quantity (grade) of metal found in an ore body and that can be economically mined is relatively low in most non-ferrous metal deposits. This means that the amount of waste left after recovery of the metal is therefore virtually the same as the amount of ore processed. Furthermore, to allow access to the ore, overburden and waste rock may need to be removed, increasing the total volume of waste. Table 1 provides estimates of the amount of ore mineral and the percentage share that becomes waste.

Table 1. World Ore and Waste Production for Selected Metals in 1995.

Metal	Ore Mined (million tonnes)	Share of ore that becomes waste, not including overburden (%)
Iron	25,503	60
Copper	11,026	99
Gold	7,235	99.99
Lead	1,077	97.5
Aluminium	856	70

Source: Gardner and Sampat (1998)

A mineral deposit without a viable waste disposal option is not a viable mine. The development of viable waste management options at any new mine is crucial. It is crucial not just to the company, but also to local communities and the environment. Technological advances and changes in regulatory regimes have resulted in significant changes in waste management practices over the last 10 to 20 years. Mine waste management practices use common design principles but the detail is dependent on the specific site conditions. There

[1] Note that 'waste' is used as a collective term for a number of components (such as overburden, waste rock, tailings) as described in Appendix A.

are therefore no universal solutions for waste storage facilities that can be proposed or applied; only guidelines.

From a review of the historical practice of managing large volume wastes, two areas can be identified for change in the way the mining industry conducts its business. These are improved environmental performance and greater inclusion of stakeholders in decision-making. If these goals represent the wishes of society as it makes the transition to sustainable patterns of development, what would be the impacts on the mining industry? Improved environmental performance could incur additional costs that potentially could change the viability of a mining project. Alternatively, these additional costs would be passed on to the consumer through higher commodity prices.

This increases the incentive for some operators to circumvent the higher standards and their associated costs with the risk of creating a two-speed industry. This raises the issues of incentives and penalties for the fair operation of a single global market. It also increases the likelihood that the market share of mineral products will be lost to substitutes that may have their own significant environmental and social costs. The aim of any fundamental shift in the management of large volume waste should be to keep mining profitable for those companies which make commitments to change and deliver on those commitments, whilst penalising those companies which do not.

Mining operations are finite economic activities. They are usually relatively short term, with a typical life span of 30 to 100 years. For a mining project to make a positive contribution to capital stock closure objectives and impacts must be considered from project inception. Mine sites that are no longer in operation and have been 'abandoned' represent a negative contribution to the natural capital account bequeathed by past generations. These sites are found in virtually all regions with a history of mining and, while it is impossible to estimate exactly how many present an environmental risk, some databases in the US suggest that it is about 5% of all abandoned mines.[2] This does not indicate the local magnitude of such environmental risks. One way to create a credit in the current natural capital account would be to deal with the worst environmental problems at abandoned sites. Improving these sites could create benefits, which could offset or perhaps even exceed any deficits attributable to current and future operations.

The overall objective of this document and the associated appendices is to explore the issues related to the management of large volume waste, mine closure and abandoned mines.[3] Technical issues are described in the annexes while the first part of the report outlines best practice, the drivers, decision-makers and recommendations for improving the operation and closure of mining projects so that there can be progress towards sustainable development. The annexes include the report of the MMSD Large Volume Waste Workshop held in Vancouver in July 2001. This document is the basis for informing parts

[2] See http://www.mbmg.mtech.edu/env-abldbms.htm

[3] The sensitivity about definitions of terms is recognized; this issue is further addressed in the Appendices to this report.

of the MMSD Final Report, *Breaking New Ground*,[4] especially Chapter 10. Some information in this section is repeated in the MMSD Final Report.

2 Best Practice

The concept of Best Practice dominates discussions of improving environmental performance in the mining industry and in making decisions on waste management options and mine closure more inclusive. However, unless the meaning of Best Practice is agreed, the term is meaningless and its use is often misleading. Best Practice may be defined as the methods and techniques that have proved to lead to successful outcomes through their application, but different interest groups will almost certainly have different views of what constitutes a successful outcome.

What is clear is that it would be easier to describe Best Practice as a process rather than specific design elements. This is because the optimal decisions will be established on a site specific basis, using a consistent process, and will result in design elements that differ from site to site. For example, there will never be a universal numerical value for the minimum freeboard to be maintained in tailings disposal facilities, but the correct process for establishing what that freeboard should be at a given site can be applied anywhere. The process of Best Practice can then be supported by guidelines that relate to the technical or design issues. These guidelines will serve as a framework rather than a prescriptive formula.

This way of seeing Best Practice – as a process rather than as a series of design elements – will mean that the outcomes will differ from place to place. It is most important that the same process has been followed in each case. This process means involving all interested and affected parties in the identification of options, the analysis of options and the selection of a preferred option for waste disposal.

This is not to suggest that efforts to identify and spread good practice in the physical techniques and methods used in the management of mineral wastes should not continue. Some initiatives, such as the several publications of the International Commission on Large Dams (ICOLD) and the Mining Association of Canada (MAC) on tailings dams, have already reported and others are planned. They are guidelines that consist mainly of advice allowing for some flexibility in interpretation. It may be possible to agree to some elements which constitute minimum acceptable requirements, and which may be put forward as international standards, but these are unlikely ever to cover the full range of activities involved in the design, construction, operational management and decommissioning of large volume waste facilities.

Some interested constituencies may be frustrated that producing a universal guide to the principles and practice of large volume mineral waste management does not seem feasible. With site physical, biological, social and economic conditions varying so much, and with the model of sustainable development requiring trade-offs between environmental, social and economic aspects where necessary, this is always going to be an unrealistic expectation. It is

[4] MMSD (2002) *Breaking New Ground. The Report of the Mining, Minerals and Sustainable Development Project*. Earthscan Publications Ltd.: London.

in the interests of all stakeholders to work instead on defining a process that can reliably produce Best Practice outcomes.

3 Sustainable Development Drivers

During the process of developing a mining project and during the operation of a mine any decisions that are made take into account a number of considerations. These considerations are currently the drivers behind the decision-making process. A comprehensive approach to waste management and mine closure involves the analysis of these drivers in a balanced way. The following section attempts to describe all the drivers—including the related issues—that should be considered during the decision-making process. The issues described in this document will apply very differently to the 'best players' in the industry than to the 'free-riders' reflecting the 'two-speed' industry. The drivers included in this section represent the norm and the ideal and are discussed under the following headings:

- Environmental
- Socio-Economic
- Corporate
- Regulatory

In order for the mining industry to adopt a more holistic approach to sustainable development, these drivers need to be expanded to include: increased resource efficiency, a reduced environmental burden, an equitable division of benefits, poverty alleviation, as well as Best Practice process and standards.

3.1 Environmental Considerations

Environmental considerations are increasingly an integral part of the decision-making process in the development and closure of a mining project, in order to minimise the long-term impacts. The physical and chemical characteristics of the waste and the method of disposal (see Appendix A for details) are critical to the level of impact on the surrounding environment. These impacts vary from operation to operation but a number of issues are widespread and/or have long-term implications for the surrounding physical environment and related ecosystems and on the requirements for rehabilitation and final closure.

3.1.1 Land

The disposal of overburden, waste rock and tailings in land-based facilities may have profound implications for the surrounding land-based ecosystems. If the facilities are not physically stable, erosion by wind or water, or slumping can result in chronic or catastrophic failures that can spread potentially contaminating sediments over a large area. Site selection follows a number of basic steps that aim to ensure the optimal location of the facility, and to take into consideration climate, topography, hydrology and geology. Inappropriate decisions of the siting, bad construction, or bad management of these facilities can have long term implications for their rehabilitation and final end use. In addition, as discussed in Section

3.2, land used to dispose of waste is, at least during mining operations, no longer available for other socio-economic uses.

3.1.2 Water

Mine derived pollution is one of the causes of water degradation in many parts of the world. Potential sources of pollution from a mine site include mine water discharge from underground and open pit mines and leachate or runoff from waste disposal facilities. While the location of a mineral deposit cannot be changed, the choice of mining method and waste disposal sites can. These decisions may have profound implications for the surrounding aquatic environment.

The most serious and pervasive environmental problem facing the minerals industry today is acid drainage. The degree of acid drainage generation and impacts are site-specific and determined by the geology and climatic regime as well as the method of mining, processing and waste disposal. The early recognition of the potential for acid drainage is essential for its successful management. Tests to characterise the mine rock help indicate an acid production potential, then a risk analysis can provide the framework for a risk management plan that includes design and management of waste facilities in order to minimise the production and migration of acid drainage and its impacts.

The presence of residual quantities of the chemicals used in mining and mineral processing in the tailings may also have an impact on the surrounding environment. These impacts need to be taken into consideration when decisions are made on processing methods and disposal of wastes. Site-specific combinations of chemicals should also be evaluated.

3.1.3 Riverine Disposal

A small number of large-scale mining projects currently use riverine disposal of waste. The disposal of large volumes of waste into a river system has the potential to cause serious environmental and social impacts downstream. These include increased sediment load and deposition, elevated metal and other minerals levels, acid drainage from over-bank deposition and significant biological impacts. However, this method of disposing of waste material avoids the cost of building land based storage facilities and reduces the physical footprint of the project. It must be noted that for the three projects where this method of disposal is presently used, land disposal options were not a viable alternative because of the lack of stable land and the high rainfall. The alternative option was 'no mine'. If this option for waste disposal is ever considered for future projects these impacts and benefits must be taken into account in the decision-making process.

3.1.4 Marine Disposal

Marine disposal of mining waste is defined as the discharge of mining wastes, including tailings or waste rock, at varying sea depths. The environmental impacts from shoreline and very shallow discharge are generally severe. Deep sea or submarine disposal of tailings involves deposition at depth so they remain on the sea floor below the most biologically active zones. This method limits the environmental impacts associated to shallow and

shoreline marine disposal, but has not undergone long-term validation. Marine disposal of tailings again avoids the cost of building storage facilities on land thereby reducing the physical terrestrial footprint of the mine site. All these issues need to be taken into consideration when establishing waste disposal methods.

3.1.5 Scientific Analysis and Risk Assessment

Mine waste management decisions are usually based on 'available scientific knowledge'. Past predictions have often underestimated impacts or were completely erroneous. Though modelling and predictive capacity has improved over the years, scientific limitation and possibilities for mistakes still exist. Lack of scientific knowledge can thus result in significant unexpected impacts that may or may not have been identified by a risk assessment. In some cases, disposal methods with known impacts may be used because of a lack of knowledge of better options with unpredictable impacts.

When making decisions on mining and processing methods and waste disposal alternatives the level of confidence in the predictions should be taken into account. Where the level of confidence is low it would be advisable to carry out a detailed risk assessment to ensure that the selected options do not present unacceptable risks to the physical or social environment.

3.2 Socio-Economic Considerations

Socio-economic implications need to be taken into consideration in order to minimise the long-term impacts and maximise potential benefits. Socio-economic considerations are typically included as a separate section of the Environmental Impact Assessment. This is usually not done until a large proportion of the initial planning has been completed and is particularly true for the method of disposal of waste and the siting of waste storage facilities. Community consultation, participation and development are essential to ensuring that the company identifies the concerns of the community and takes these into account in the planning, development and closure of a project and the community's involvement in the decision-making process.

It is important to acknowledge that perceived changes may have the same socio-economic impacts as actual changes. This is particularly the case for impacts, such as water quality, which may be difficult to assess with the naked eye. In order to overcome perceptions that may not be based on scientific fact it is necessary to build trust through meaningful engagement of local communities and potentially impacted parties. This needs to be undertaken from the beginning and continue throughout the project life cycle for all decision-making processes.

A consideration of the socio-economic impacts needs to establish the type, duration, spatial extent and distribution of the impacts. This incorporates: what to include (direct *versus* indirect impacts); what period of time (exploration to closure and beyond); what area to cover (the boundaries of the impact zone); and who will be affected. The socio-economic issues associated with the disposal of waste include:

- Loss of productive land, subsistence land uses, or culturally important sites
- Loss of clean water

- Loss of a resource (such as fishing)
- Health impacts

The use and value of land invariably alters once it becomes a waste disposal site. The temporary (during operations) or long-term loss of these lands is one of the principal socio-economic impacts from mining operations. Any mining operation resulting in degraded water quality and increased sediment levels can prevent the use of river water for drinking and cooking. Other potential uses of water are also affected, such as agricultural, irrigation, livestock or industrial uses. These impacts depend on the availability of alternative water sources. Increased sediments and degraded water quality in river systems can also influence fish behaviour thereby affecting subsistence or commercial fishing. The discharge of sediments or polluted waters to the coast could imply that ocean fishing may be affected. Exposure to water bodies with increased levels of metals and other elements is a potential negative impact. In dry climates, increased dust levels can result in respiratory metal ingestion.

At each mining site, site-specific risk assessments must be done to investigate socio-economic impacts. For example, the environmental changes caused by riverine disposal inevitably have socio-economic impacts on downstream communities. Physical changes, such as degradation of water quality, widening of river channels, changes in flow, over-bank deposition of tailings and flooding can impose a number of alterations in community lifestyles. However, the scale of these impacts depends on the pre-mine uses of the river. In areas that were not originally used because of inaccessibility, excessively fast flows, or naturally poor water quality, the socio-economic impacts are limited.

3.2.1 End Use

The intended end use of mine waste facilities should also be taken into account when assessing waste disposal options. Considering possible end use from an early stage of mine planning activity could influence waste management practices and the level of potential environmental and social impacts. An important aspect of mine planning is the rehabilitation of waste disposal sites to a stable and productive post-mining landform, which is suitable and/or acceptable to the community. The essential goal of site rehabilitation is to leave all affected areas, as near as possible, at an optimum environmental, social and economic 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 to a level that does not pose a significant environmental or human health problem, to restore the land and landscape, to improve the aesthetics of the area and to prevent further degradation. Through consultation with relevant interest groups, including the regulatory authority, traditional owners and private owners, the mine operator can establish the required future land use for the different waste disposal facilities. This should be done as a multi-stakeholder consultation process.

In most cases in the past the final end use for the waste disposal facilities have not been clearly established until the economic reserves were nearly depleted and the closure of the mine was being planned. This can restrict the options and increase closure costs, even though the end result may be seen as a success. Decisions on the end use of waste disposal facilities, or the waste, must evaluate health and safety implications and environmental risks.

These may be in the form of physical danger, heavy metals in soils and/or water or plant uptake of metals. It may also include direct human contact with contaminated areas.

3.2.2 Public Opinion and Expectations

It can be argued that public opinion has been the most important driver for changing waste disposal practices, and associated regulations, so that environmental and socio-economic impacts are considered. The number of high profile accidents at tailings storage facilities has accentuated this. The 'not in my backyard' reaction can put enormous public pressure on waste disposal practices on a local, regional or even national level. This can go to the extreme of precluding mining altogether.

Public opinion is a powerful tool for change, but can be reflected differently by distinct groups of stakeholders. Local communities, regional and national administrative authorities, and local civil society may have divergent views on the environmental and social impacts of waste disposal. Global NGO's may reflect the standards of their own countries. How effective these groups are at influencing waste disposal practices depends on their capacity, and the relationship they have with the government, mining company and international community. As information exchange systems improve, networking and capacity grows, increasing the ability of certain groups to influence waste disposal practices.

Mistrust of corporate statements and reporting is one of the most important factors influencing public opinion. Mistrust exists because of traditional corporate naiveté or unwillingness to make information widely available, and to assume responsibility for environmental and socio-economic impacts. On the other hand, there exists mistrust in NGO statements and reporting. Transparency in impact analysis and waste disposal decision-making is vital to overcoming this mistrust. Overcoming mistrust is a two way street, and goodwill and effective, ongoing communications are also key parts of a process for all actors involved

3.2.3 Mining Benefits and Compensation

In spite of the negative environmental and socio-economic impacts that may result from mining waste, countries and communities sometimes welcome mining with any method of waste disposal, because of potential benefits. The presence of a mine can be a vehicle for development in remote regions. The benefits associated with a mining operation can include royalty payments, land rent, job creation and infrastructure development including roads, power production, water distribution, construction of schools, hospitals, etc. These potential benefits, along with the associated economic development of the region, can be a powerful consideration in the approval of a mining project. Regions that are not desperate for economic development have the 'luxury' of being able to reject a project; the no-mine option.

To counterbalance mining impacts, compensation payments are often offered to the local community in the form of one-off or regular cash payments for a real or perceived loss of a resource. They are classified not as a 'benefit' of mining but as a 'neutraliser'. In some

instances compensation payments may be used for regional development. The nature and level of compensation payments should be a part of the decision-making process.

The closure of a mine invariably affects economic activity and community development in the mining area. Measures to deal with job losses and other impacts on economic activities exist, but are not always implemented in mining areas. The sustainability of community activities that are directly or indirectly supported by the mine is also put at risk and measures to maintain them can be incorporated into a mine closure plan.

3.3 Corporate Considerations

3.3.1 Costs

Economic considerations are an important driver behind many decisions throughout mine life. Waste disposal can represent an important cost consideration, sometimes resulting in choices that lead to significant environmental and social impacts. The selection of a particular disposal option or siting decision can be a direct result of this driver or a compromise between economic and other considerations. Whom this information is made available to may also influence how the decisions are made. Balancing economic considerations with other factors is one key to responsible waste management.

- Project evaluation models are used to determine the economic feasibility of potential mine projects. Economic considerations play a major role. As well as establishing if a deposit is economically feasible to mine, this model also influences decisions on the location of facilities, method of mining, and methods of waste disposal. Current good practice includes a sequence of evaluation stages, usually culminating in a full feasibility study, through which uncertainties about all aspects of a project's viability are identified.
- Discounted cash flow analysis is used in project evaluation models. For long-term projects, future costs (>20 years) have little impact on feasibility decisions because the present value of expenditures far in the future are very low when discounted. This type of analysis also favours capital cost savings at the beginning of mining projects over operating costs (including mitigation costs), although the decision is always based on the balance between capital and operating costs. Assuming that several disposal methods are equally technically feasible, this type of analysis will favour the option involving lowest capital costs, even though high costs because of environmental impacts may result many years down the line. For waste related decision-making, discounted cash flow analysis only represents a part of the whole picture, and the impacts of long-term costs are not consistently addressed throughout the industry.
- Addressing the whole picture means including environmental and socio-economic impacts into project evaluation models. Valuation and representation of these external costs is typically based on mitigation and remediation costs. These do not always adequately represent the full scale of environmental and socio-economic costs. Different methods to economically value 'ecological goods' often result in discrepancies (van Kooten and Bulte, 2000).
- Environmental and socio-economic costs are usually assessed and balanced against economic costs internally and this information is considered sensitive and only available to the company and the regulatory authority. When this is the case, affected/interested

parties are asked to make value judgements without the benefit of this information. The lack of information relating to this driver may bias the decision-making process or may make groups feel left out.

Providing adequate funds for closure and post closure monitoring and maintenance is a vital part of the decision-making process. Closure cost estimates are used by mining companies to provide funds for closure and by regulatory agencies to establish financial surety to pay for closure in the event of a failure by the company. It has been common in the past to base 'reclamation' costs on a unit of disturbed area. Recent experience clearly indicates that the 'reclamation' cost is lower than the 'closure' cost and underestimates what is required for financial surety. A complete closure design must be established to estimate the closure cost, based on realistic assumptions about closure technologies and implementation, including the time it would take to complete.

3.3.2 Policy/Culture

Corporate environmental or sustainable development policies are beneficial from both legal and public perspective as they set out the broad policies of the corporation. How these policies are translated to each mine site is very important. There may be a big difference between how upper management sees these policies and how they are incorporated into the site decision-making process. There should also be a clear alignment of management procedures, and systems of positive and negative incentives, not only for production but also for sustainable development issues.

Industry codes, for example, the Minerals Council of Australia Code, may also act as a driver in the decision-making process. They are important in setting out the broad expectations and guidelines for the industry though their overall influence in changing the way a company operates is still not clear. For industry codes to be effective, there need to be rewards for those who participate and comply and punishment for those who do not.

Many mining companies now report annually to their shareholders on environmental, social and sustainable development progress. Such reports may include performance indicators, targets, and benchmarks that are important reference points for assessing the performance of the company. While these reports are useful, they may also be seen as propaganda if they do not present the information accurately or clearly. However, the requirement to publicly account for their actions may influence a company's development and operating decisions. Companies are now also more concerned about their 'corporate image', especially in regard to environmental issues.

3.4 Regulatory Considerations

3.4.1 Legislation and Policy

Legislation and policy are also drivers that control the mining impacts through the decision-making process. These may come in the form of laws, regulations and guidelines and government policy. Some countries have developed legislation that is over-prescriptive, severely hindering the development of a project, while others address minimum standards

only. The majority of countries do not have legislation that is capable of promoting sustainable development. Legislation is developed reactively which means that good industry performance will result in less prescriptive legislation.

Guidelines on waste management and mine closure have been developed at international, national and regional levels and these need to be taken into consideration in designing and operating a mining project. Guidelines are rarely legally binding though they do provide an advisory framework aimed to assist in various activities and maximise opportunities.

There is often a conflict of interest between various government policies, environmental legislation and other laws and regulations. This is most pronounced in the conflict of interest between the wish to attract mining investment and the need to maintain high environmental standards. The government holding equity in the project further compounds this situation. Although these are all obvious drivers in the decision making process the potential for trade-offs becomes apparent (see Section 4.2).

3.4.2 Regulatory Authority

In principle, the regulatory authority should be a critical driver in the decision-making process, ensuring that the relevant legislation and policies are adhered to. However, regulatory authorities do not always have the resources or capability to implement the legislation or the need for development may influence the level of implementation. In many developing countries the capacity of the department responsible for environmental regulation, both in number and location of staff and their training, is inadequate as well as the resources at their disposal. Their position is therefore weak in the decision-making process and may be in conflict with the department that promotes mining, which is often better resourced. This position may be further undermined if the regulatory control of the environment is divided between a number of different authorities, each with their own mandate.

There could also be conflicts of interest between national, regional and local governments and governance of a mining activity may not take into account local factors that could result in discontent over impacts or benefit sharing. If the perceived benefits are large there is a potential for corruption.

4 Decision-Makers – Governance

Large volume waste management and mine closure involves decision-making on a number of issues. The governance structures behind this process can be as important as the decisions themselves. Balanced governance provides opportunities for a wider acceptance of any decisions. This involves identifying the interested parties and creating structures that allow for a equal input into the decision-making process. Traditional governance structures for decision-making have primarily involved the mining company and national, regional or local government. This bilateral model for governance imposes decisions on other interested parties that are not always widely accepted.

Identifying and interacting with the interested parties is necessary to understand the socio-economic issues. Engendering wider acceptance of governance structures also implies creating a meaningful consultation process. It is important to identify all the potentially affected/interested parties downstream of the operation, and not focus on one group as representative of all similar groups. The following groups are considered as potentially affected/interested parties;

- Communities local to the mine site and any associated infrastructure.
- The people of the host region and host country.
- National, regional and local government including the regulatory authorities.
- National, regional and local NGOs.
- In the case of foreign mining companies operating abroad, the 'home country' public and NGOs also have an interest in the operation.

Considering potential interested parties throughout and after the mine-life is also important, as the local situation can change from one generation to the next. Governance structures are particularly important for decisions involving trade-offs between economic, environmental and social impacts. Mining may present unparalleled economic potential in an area, but how this comes about, and to what expense, is a critical part of the whole picture.

The decision-making process needs to be transparent and coherent with the integration of qualitative values and the involvement of all interested parties. In the past it was common practice for a mining company to make the majority of decisions internally and then present them to the regulatory authority and local community for approval. Recently, a more balanced, democratic decision-making process has been advocated to promote the tenets of sustainable development. In addition, many decisions that were originally based on short-term financial considerations are now including a more broad based. The process of decision-making should involve:

- All aspects of mine development (social, economic and environmental).
- Full participation of the community and regulatory agency at all stages of decision-making throughout the mine life cycle;
- Transparency and equal access in the collection, development and use of data, including the option of an independent party reviewing the data;
- The inclusion of qualitative values and risk assessment in the decision-making process; and
- All options including the possibility of 'no mine'.

The various options and controls for decision-makers are discussed under the following headings;

- Limits
- Trade-offs
- Making decisions

4.1 Limits

Most decisions require trade-offs, in which more of one thing is gained at the expense of something else. There should, however, be limits on the trade-offs that can be made. A number of these limits must be respected in the decision-making process for the disposal of large volume waste and mine closure. Obviously, compliance with the legislation is one limit, but it may not be the only one. It is difficult to list all the potential limits, as many will be site-specific. The examples in Table 2 may, however, provide an idea of what should be taken into consideration.

Table 2. Criteria that should be part of decision-making for the disposal of large volume waste and mine closure.

Criterion	Example of unacceptable negative impacts
Material standard of living	A decision that reduces the standard of living of some people below the survival threshold, perhaps by depriving them of their current livelihood without offering them any alternative.
Social development	A decision that violates basic human rights, such as the right to be compensated for the loss of land or homes.
Equitable sharing of costs and benefits	A decision that unevenly distributes benefits between the national and local levels.
Environmental effects	A decision that allows for acid drainage to pollute a section of the natural drainage.
Building for the future	A decision that clearly leaves the next generation with less of some forms of capital without any increase in other types of capital.

At the extreme, the unacceptable impacts are easy to identify and very broadly agreed, but in less clear cases there may be considerable debate over where the limits are.

4.2 Trade-Offs

So long as we are operating within the understood limits, unless we are lucky enough to find a 'win-win-win' option, we are in the realm of trade-offs. A series of trade-offs are generally necessary to select a viable waste management option or closure plan for a specific site. These trade-offs are broader than only the technical/engineering and project economics; they are related to all the sustainable development drivers discussed in Section 3. The regulatory framework for a specific location, expected environmental impacts for a specific option, the project economics for various alternatives, and the socio-economic expectations must be evaluated and taken into account before a final decision is made. Therefore, while Waste disposal of tailings may be considered environmentally advantageous, project economics may dictate that a different waste disposal system, with a lower capital cost, be adopted.

Trade-offs for the management of large volume waste and mine closure should not be based solely on engineering and cost optimisation. They should also be based on optimising the potential for sustainable development. This may require a number of compromises. An optimum site (from a strict engineering viewpoint) may not be available and a viable alternative with greater associated cost would have to be located somewhere else. Alternatively, a socio-economic trade-off may be necessary by resettling a village or compensating owners for agricultural losses.

The key question is who makes these decisions or trade-offs. In principle, the final decision will rest with the regulatory authority though trade-offs cannot be made in isolation. The government and mining companies must engage the other interested parties in making and implementing these trade-offs. If there is broad acceptance of any trade-offs or compromises they will be easier to implement than if they are made without input of the other interested parties.

Making these trade-offs is seldom an objective process and includes subjective judgements and wishes. Documenting the decision-making process is not always simple and various methods, such as the Multiple Accounts Analysis (MAA: Robertson *et al*., 1999) have been successfully used to develop and document trade-off analyses for difficult mining-related issues However, this arena is very sensitive and it is necessary to develop engagement processes that will allow these trade-offs to be made without some communities of interest feeling left out.

A number questions remain for industry and the other interested parties to address in making the trade-off decisions:

- Does the mining company, as the proponent and investor, have specific rights with respect to site-specific decisions?
- What are the obligations of the mining company to other interested parties in making the trade-off decisions?
- Who has the control in making the final trade-off decision at a site if there are controversies remaining?

4.3 Making Decisions

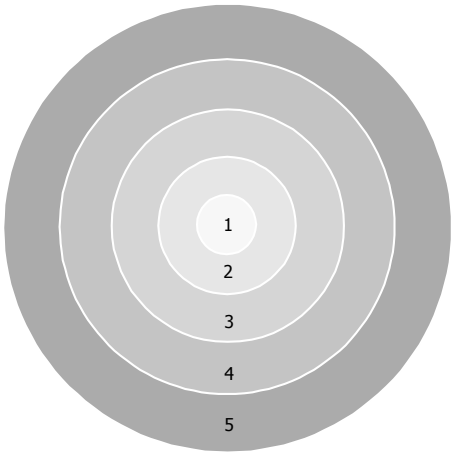
The mechanisms for decision-making on large volume waste rely on a decision framework and decision makers (including all the interested parties). A decision framework for sustainable development requires first looking at limits (see Section 4.1). Once the boundaries are established, making decisions requires a way to consider and balance a complex set of trade-offs. But all of this presupposes the existence of mechanisms through which these decisions are made. These mechanisms need to exist at several levels.

- There are some basic boundary conditions set at the international level, by agreements such as the Dumping Wastes at Sea Convention, the Ramsar Convention on protection of wetlands, the trade rules of the WTO and other international instruments.
- Within the broad limits of these international agreements the basic decision-maker for most kinds of decisions is national government.

- While different countries allocate power in different ways, there is generally also a more local level of government that is important in many kinds of decisions.

This document focuses on decisions at the national and local levels. Not all people at the national and local levels – whether they are in the majority or the minority – have the same level of interest in decisions. Figure 1 illustrates what the range of those interests may be.

Figure 1. Stakeholder Groups



1 Stakeholders with a
Examples: Duly constituted government discretion to deny permits; landowners who own rights who are under no obligation to

2 Stakeholders with a right to be
Examples: Surface owners who do not own mineral injured workers; communities requiring

3 Stakeholders with a right to
Examples: Some national indigenous agencies; planning authorities; people entitled to EIA

4 Stakeholders with a right to
Examples: Affected persons whose views sought; neighbours; non-decision-making agencies.

5 Stakeholders who should be
Examples: Suppliers; the

In the ideal model, a decision-making body, accepted as legitimate by all (or at least the great majority), and operating under clear and transparent rules, would become as fully informed as possible about all the factors relevant to sustainable development: costs, technical feasibility, and the social, economic and environmental risks and opportunities. Part of becoming as fully informed as possible would be to ensure that all those with a vested interest in the outcome were aware of the decision to be made, had a chance to understand its implications, and are given a full opportunity to express themselves to the decision-makers. This decision-making body would then balance the trade-offs that need to be made and come to a decision that in its view maximises the benefit for all within the limits of the possible. Those who did not like the result would accept it anyway, because they agreed the process had been a fair one.

Convention 169 of the International Labour Organization recognizes indigenous peoples' rights of ownership and possession over their lands and provides that the rights of the peoples concerned to the natural resources associated with their lands are safe-guarded. The Convention requires that where there is State ownership of mineral resources, governments should have procedures for consulting with indigenous peoples. Accordingly, before carrying out or permitting any the exploration or exploitation of such resources, governments should determine the impacts on the interests of indigenous peoples.[5]

[5] Office of the High Commissioner for Human Rights Convention (no. 169) Concerning Indigenous and Tribal Peoples in Independent Countries. Adopted on 27 June 1989 by the General Conference

However, civil society frequently mistrusts the quality of much of the data, information, interpretations and predictions produced by the mining industry and their consultants. It is therefore imperative that mechanisms be developed to promote 'independent' sources of information. For example, company studies should receive peer review and validation by experts that are considered suitably independent by the various interested parties. In addition, representatives of the interested parties should be allowed or encouraged to participate in data collection and monitoring programmes.

4.3.1 Challenges

In this imperfect world, decision-making mechanisms fall short of this ideal for a number of reasons. Some of the most critical are:

- *Lack of legitimacy.* Governments which have come into power by undemocratic means, or that are dominated by small unresponsive elites, or fail to protect the rights of minorities will have a difficult time making decisions that are regarded as legitimate.
- *Lack of clear and transparent rules.* Even democratic government has trouble making decisions that will be accepted if the decision process occurs in secret, the factors on which decisions are based are unclear, or some interest groups have more access than others to the decision-makers.
- *Failure to get good information.* Where the decision process operates under clear rules in a transparent environment, it is still unlikely to produce good and accepted results unless there is a process such as a rigorous impact assessment or a series of good baseline studies that bring forward the full range of information for consideration.
- *Inability to make necessary trade-offs.* Sustainable development requires a balancing of a group of factors: economic, social, and environmental opportunities and risks, short and long term. But most government agencies have responsibility and authority for only part of this range: the environmental, or the economic, for example. Unless ways can be found to bring the various responsible government bodies together, it will be hard to do the necessary balancing.
- *Lack of clear and accepted national – local boundaries.* Where there is tension between local populations and national government and no clearly defined role for each it is hard to reach satisfactory decisions. In countries with wide regional and ethnic differences, control over such things as mineral revenues can be highly divisive, and local decision-making power can be seen as threatening to the integrity of the state
- *Failure effectively to inform affected populations.* Where information is not timely available, is evidently incomplete, or the recipients are not given the time, or lack the capacity to assimilate it, they cannot participate effectively in the decision process and the result is unlikely to be regarded as legitimate.
- *Lack of effective access to the decision process.* People who have no way to express themselves effectively to decision-makers are unlikely to trust or accept the result.

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of the International Labour Organisation at its Seventy-Sixth Session. Entry into force 5 September 1991.

- *Failure to respect minority rights.* Even when a decision accurately reflects the interests of the majority, it is unacceptable if it does not incorporate basic respect and protection of the rights of minorities. For example, building a highway may be in the overall social interest, and individuals living along its path may have to give way. But we do not expect them to have to give up their homes without compensation or resettlement.
- *Lack of capacity.* Even where government is attempting to implement sound decision-making processes, it may lack the overall legislative framework to do so, or simply lack the skilled people or financial resources to do the job. Lack of capacity of other actors may also inhibit effective decision processes.
- *Failure to follow up.* Even good initial decisions will not work if there is no ongoing monitoring mechanism to ensure they are implemented, and for considering mid-course corrections as circumstances change and new information is developed.

There is most probably no government decision-making process in the world that could not be improved. Because the process depends so much on human and financial resources, there are likely to be greater problems in countries that lack those resources. Indeed, that is one of the reasons that development is needed: to provide the resources to ensure more effective governance.

Decisions must be made despite the defects in decision-making processes. The goal can only be to improve governance over time, and to make the best possible decisions as that process goes forward. Doing that will require two things:

- Decision processes must start with the need to incorporate and comply with all exiting legal requirements; but
- All those involved in the process must realise a need to go beyond compliance, supplementing the legal minimum as necessary to ensure that the results have the highest degree of legitimacy and acceptance that is realistic in the circumstances.

4.3.2 Getting Better Decisions

Globalisation has created all kinds of opportunities. It has not only created opportunities for development, but has also improved the availability of knowledge about issues and decisions to a much wider audience. It has also created complex systems of economic activity and decision-making that are, as is the case with all complex systems, vulnerable to blocking strategies.

Blocking strategies are a method of preventing things from going forward or increasing the price if they do. They have an important role where decision processes are so flawed that they fail to meet minimal criteria or fairness, majority rule, or protection of the rights of minorities. But blocking strategies are not always a legitimate tool. They should not be used to frustrate democracy, undermine sovereignty, or serve ulterior motives.

There is probably no better way to resolve these problems than to say that majority rule and the protection of the rights of minorities are the two principles that must underlie decisions. Unless government is decidedly undemocratic, there must be a presumption that national

and local government are the vehicles through which the popular will is expressed. Their decisions should therefore be respected so long as they are complying with legal norms and respecting the rights of minorities.

Developing country governments face many challenges. Maintaining their sovereign right to make decisions is one of them. There are all too many instances in which all kinds of interests in the richer countries have their handles on levers of power that can serve to block the aspirations of democratically elected governments in developing countries.

Protection of minority rights is a key issue. There are those who advocate a policy that projects should not proceed until everyone who considers him or herself impacted gives their consent. This is an enormously burdensome requirement. Very few new national parks would be established if this were the requirement, and very few pollution standards would be adopted. Similarly, very few rail lines or highways could be built, and very few minerals projects would be approved. In fact, very little could get done.

Minorities have two kinds of rights. First, they have procedural rights to fairness and transparency in decision processes. Second, if they are being asked to give way for the greater good of the majority, they need to be compensated for what they lose, according to emerging norms dealing with resettlement, compensation for loss of livelihoods, payment for loss of property rights and the like.

While the goal is to ensure that government has the capacity to make informed decisions in ways that are broadly agreed to be legitimate, the industry operates in many places where government now falls short of this ideal. The interest of companies are less served in these environments by getting permits in record time than by building long-term relationships with local actors. This requires company strategies oriented towards that goal, rather than simply complying with legal minima. The issue is how to get fair, broadly accepted decisions. Where the legal and regulatory system is weak, international codes, guidelines, etc. may play a critical role.

5 Abandoned Mines

It is impossible to estimate the number of former mining sites that exist around the world or the extent of the negative legacy that they represent. The Abandoned Mines Working Paper (Appendix C) summarises some of the available information. The issues associated with abandoned mines include physical, environmental and public safety concerns. In countries with a long mining history the magnitude of these impacts is often considerable and the costs of 'cleaning up' these sites are daunting. Although the most important issues associated with abandoned mines are the safety hazards and environmental risks posed by physical and chemical stability, public opinion is usually initially focused on visual impacts. Attitudes towards the responsibility for addressing this legacy vary between developed and developing countries and between individual countries.

Abandoned mines represent not only a major liability for the government but for the affected communities, adjacent areas and society at large. Some jurisdictions, mostly in the US, have programmes in place to educate the public of the physical dangers of abandoned

mines. These programmes also undertake special efforts to reclaim abandoned mines or to fence and post signs at shafts and other dangerous locations.

Mines that have been abandoned by a company may attract legal or illegal small-scale miners who rework the waste or extend the existing workings. These miners often have no formal training and their methods and use of chemicals can result in impacts on the environment and in particular, natural water resources.

In a number of countries attempts are being made to produce abandoned mine inventories and to rank the sites in order of priority for rehabilitation. Different regions have different criteria by which they priorities abandoned mines for rehabilitation. Typically the criteria used focuses first on public health and safety and then on the environment. In some jurisdictions these criteria are built into the legislation.

When there are no identifiable owners or the owners have gone bankrupt, the question of who funds the 'clean up' is paramount. If another mining company is interested in the site they may be persuaded to assume responsibility for any abandoned mines within the licence area. Where this is not the case, various mechanisms have been developed to pay for the rehabilitation of abandoned mines. For example, in Tasmania the government has established a trust fund that can be used to clean up abandoned sites. However, it is more common for the burden for their reclamation and rehabilitation costs to rest on public funds. Table 3 outlines a possible division of responsibility for the rehabilitation of abandoned mines.

Table 3. Possible allocation of responsibility for dealing with mining legacies

Scenario	Responsibility
Ancient mine workings.	Rehabilitation with public funds.
Historic mine with no identifiable owner.	Rehabilitation with public funds.
Mine closed and former operator can be identified, but no longer owns the site.	Former owner could be liable or could be a public responsibility.
Mine closed but former owner still owns the site.	Owner/operator is responsible for preventing damage to neighbouring property and controlling hazards.
Mine is still operating.	Owner/operator is responsible through an agreed closure plan.
Operating mine early in project life.	Owner/operator is responsible through an agreed closure plan
Permits granted but no operations have yet started.	Costs fully internalised to the extent current scientific and technical understanding permit.
Mine has not yet received necessary permits.	Costs fully internalised to the extent current scientific and technical understanding permit.

The alternative ways of generating a fund for abandoned mine work is discussed at some length in Chapter 16 of the MMSD final report, *Breaking New Ground*.

6 Recommendations

The following recommendations have been developed based on a review of the information contained in the Large Volume Waste, Mine Closure and Abandoned Mines Working Papers (Appendices A, B and C) as well as the comments and proceedings of the Large Volume Waste Workshop (Appendices D and E).

6.1 Best Practices and Guidelines

Best Practice Guidance – To improve the management of large volume waste and mine closure it would be advantageous to develop a 'Best Management Process' supported by Guidelines for technical and design frameworks. This may mean that design and management of large volume waste facilities will differ from place to place but that in each case the same process has been followed. In this process of using the best management process all interested parties should be involved in the identification of options, the analysis of options and the selection of a preferred option for waste management and the best route for mine closure.

International Guidelines – There are no clear international guidelines for large volume waste, mine closure and abandoned mines. There may be some local or regional guidelines that can be used to develop international guidelines. For example, the Chamber of Minerals and Energy of Western Australia has published its 'Mine Closure Guidelines for Mineral Operations in Western Australia'. It is recommended that international guidelines be developed through the application of best management process by multi-stakeholder workshops. These guidelines can then be used by governments to support regulatory development. Typical topics for guidelines include: tailings storage facility management, public engagement, waste rock management, closure planning and implementation, water management, and waste disposal decision-making.

6.2 Industry, NGOs and Government

Industry Management/Corporate Culture – There is much distrust in the performance of the industry with respect to the environmental and social impacts of large volume waste. A corporate culture change is necessary in most cases to allow recognition of environmental and social accomplishments of site managers to the same level of importance as meeting production targets. If a company accepts and sees business value in the promotion of sustainable development values, including the practices for the design and management of large volume waste facilities, it is imperative that clear messages reach the operations level, backed up by rewards and sanctions through remunerations and promotion. This could be accomplished through a clear set of company policies.

Relationships – Relationships between the industry and the NGO community as it relates to large volume waste and other mining issues is at a low point. It is recognized that both these groups do not speak with a single voice, however it is important that progress be made in developing a dialogue that can be mutually agreed upon.

NGO responsibilities – While it is clear that there are differences in the behaviour and culture of members of both the industry, NGO and other communities of interest, it is essential that peer pressure, or other approaches, be used to encourage better practices in each of the communities. For example, the 'mining industry' does not necessarily speak out when poor management at a mine of one of their community results in a spill. Similarly NGOs should speak out when inaccurate claims which conflict with their knowledge and understanding are made by other NGOs.

Government responsibilities – Governments have clear responsibilities to promulgate and implement regulatory frameworks for large volume waste, mine closure and abandoned mines. They also have the responsibility for having a staff with a high level of technical knowledge and capacity to review permits and enforce the regulations. Government responsibilities also include defining outcomes and assessing the attainment of those outcomes.

6.3 Engagement and Decisions

Public Engagement/Participation – The first task with respect to public engagement and participation is to identify the interested parties associated with a specific project so that effective engagement can be established. Engagement of the neighbouring communities (and other stakeholders as appropriate) should start during the exploration phase for a project and must continue throughout development, operations and closure. In most cases it will be necessary to build capacity amongst the stakeholders, this may take the form of financial assistance and other approaches. Companies must be transparent in all their interactions with the stakeholders. It is recommended that stakeholder participation guidelines be developed to guide mining companies in their public engagement/participation activities.

Decision-making – Decision-making should be done with involvement of the community and regulatory agencies at all stages of the project. The qualitative values of the stakeholders should be considered in the decision-making processes. Risk assessment approaches can also be used in making these decisions. The 'no-mine' alternative should always be on the table. It is recommended that the decision-making processes at all stages of mining should be investigated through a multi-stakeholder process.

Peer Review and Validation – Many different analyses and models are prepared during environmental impact assessments, mine development, operations and closure. Many of these are used for internal trade-off studies and alternative evaluations while some are used to obtain permit approvals. It is essential that analyses and models used for permit approvals be peer reviewed and validated. The funding and technical support for this review could come from individual projects or companies or from the Sustainable Development Support Facility discussed in Chapter 16 of the MMSD final report, *Breaking New Ground*.

Information availability and accessibility – It is important that information about a project be available and accessible to all interested parties. Governments must make sure that public information is widely distributed; it is also to the advantage of the mining company if this can be accomplished. Apart from making the information available it may also be necessary

to provide for the capacity to interpret and understand the information; governments and companies can help to make the expertise available to help with this task.

Trade-offs – Many technological trade-offs are necessary in the development of a mine. Some of these trade-offs are necessary in the development of a mine. Some of these balances specifically concern the mine, such as site layout and mine closure. Another set of trade-offs deals with metal recovery methods, such as cyanidation and flotation. It must be recognized that many such evaluations of competing considerations are made when a mine is developed. It is recommended that a system of logical steps be developed to make these trade-offs such that all aspects of sustainable development are addressed. This methodology must result in a balancing of the sustainable development factors.

6.4 LVW Management

Good Baseline Data – It is necessary that comprehensive baseline studies be undertaken at new mines so that statistically valid information can be obtained for the evaluation of the site conditions before any development as well as the potential impacts of the proposed actions.

Stewardship of Tailings Facilities – Guidelines of good stewardship on the design, construction, management and closure of tailings storage facilities should be established. These should include scope and treatment of baseline data, method of recording the history of construction and operation and an ongoing safety evaluation programme and a closure plan. Continuity of management and independent review process should also be addressed in these guidelines.

Riverine Disposal – There should be a clear commitment by industry to eschew this practice for any future projects. At ongoing projects it is recommended that site specific risk assessments and mitigations be implemented to advance their contribution to sustainable development.

Marine Disposal – A programme of independent research should be implemented to assess the potential risks of marine disposal and in particular deep-sea disposal. This programme will pay specific attention to baseline studies at the proposed deep-sea disposal sites and will develop ongoing monitoring during and after operations.

Acid Drainage – Acid drainage is the most significant water quality issue that the mining industry, governments and society must deal with. There are a number of past and ongoing national and international research programs to address the issues of characterization, modelling and evaluation and mitigation. While significant strides have been made in all these areas, much additional work is required to provide cost-effective long-term solutions. It is recommended that public and corporate funds be made available for further research and development in this area.

6.5 Mine Closure

Closure Plans – Closure plans should include site closure issues as well as economic, social and employee matters. Closure objectives and plans should be developed in close partnership with the communities who might be affected by closure as well as the regulatory

authority. This means that options for closure plans are provided upfront to all involved in the decision-making process and these plans should include the costs. Input from the communities should be sought about future economic development options following the completion of mining, specifically the diversification of the local economies. Completion criteria are an important part of any closure plan as no mine can be considered closed (or 'completed') until all stakeholders have agreed that the required outcomes have been attained. These criteria could be defined at the EIA stage and mine performance could be measured against them throughout operations.

Closure Cost Calculations – Closure cost calculations must be based on appropriate closure technology and estimated according to the cost of *implementing* rehabilitation and socio-economic closure measures rather than just according to re-vegetation costs only. Closure plans and cost estimates must be reviewed regularly during the mine life so that the ultimate plans and costs are as realistic as possible.

Financial Surety – Financial surety regulations should be established in all countries where mining takes place. These should be implemented so that society is protected from large rehabilitation costs in the case of bankruptcies. The amount of the surety should be based on a realistic closure plan for the site.

Post Closure Environmental Monitoring and Management – Ongoing environmental monitoring during the post-closure period is a very important consideration at all mine sites. For example, there may be ongoing water management and treatment activities for a number of years following closure, in some cases in perpetuity. These activities will have to continue for a sufficiently long period of time to make sure that there will not be any further impacts from the mine and its facilities. It is impossible to estimate up front what the exact period may be. As a result, it is important that the mining company develops a plan for ongoing monitoring and reporting to regulatory agencies and other stakeholders. Such a plan must be approved before its implementation and will typically call for ongoing reporting and meetings to review the results. Sufficient funds must be committed for this, which may require long-term financial surety to remain in place. In addition it must be clear that an agreed responsible body with the capacity to undertake these activities for the necessary time period is established.

Post Closure Socio-Economic Management- Just as it is necessary to monitor and manage environmental aspects after mine closure, similarly it is necessary to manage socio-economic conditions. During the closure planning clear steps must be developed for mitigating, as far as possible, the socio-economic impacts of mine closure. It is typical to develop plans for transferring health care and education to government control in the communities following mine closure. It is important to monitor the success of these activities and to provide extra support where necessary. It is recommended that the industry work closely with government in establishing this.

Discounted Cash Flow (DCF) analysis for mining projects. – The outcome of a DCF analysis is not sensitive to projected expenditures in 20 or more years; it therefore does not provide a complete picture of the effects of long-term costs and benefits for mines. It is

recommended that multiple economic models be used to consider the long-term costs and benefits for a mine, including undiscounted cash flow analysis.

Accounting Practices – Acceptable accounting practices in some countries require that all environmental liabilities, including closure costs, be reported and included in the annual financial statements of publicly traded corporations. Mining corporations in countries where this is not required could therefore be at a competitive advantage with respect to the rest of the industry. It is recommended that all companies include all liabilities in annual financial statements. It is also recommended that a review be made of accounting procedures to make sure that this issue is addressed adequately by the annual reporting.

6.6 Abandoned Mines

Abandoned Mines Funding and Rehabilitation – The first priority is to obtain funding for the development of inventories of abandoned mines and to prioritise the sites for rehabilitation. Once this is done there will be a better understanding of what it will cost to rehabilitate the sites where there are specific hazards and environmental impacts. The costs associated with rehabilitation of these sites can be very high and it is recommended that funding mechanisms be developed on a country specific basis. Industry should work with governments and other communities of interest to provide the framework to constructively work together on the development and implementation of solutions to funding and rehabilitating priority abandoned mine sites.

Abandoned Mines Inventory – There are numerous abandoned mines databases available. These have typically been compiled by various government programs, which develop their own definitions of 'mines', 'relative impact' and other factors. It is recommended that a set of international guidelines be developed in multi-country meetings for the identification and prioritization of abandoned mines. This will also help to accomplish more effective dissemination of international experiences and hopefully accelerate the rehabilitation process.