

## MINES CLOSURE STRATEGY

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**Abstract:** Basic standards for the process of mines closure are much more demanding and complex than they were several years ago. By the mines closure is necessary to prevent or reduce to a minimum a long-term negative impact on the environment and enable the creation of self sustaining natural ecosystems.

Issues relating to mines closure are of great importance in the evaluation of proposals for the exploitation of mineral resources.

**Key words:** mine closure, environmental protection

### 1. INTRODUCTION

Closure of the mine is a series of related activities that begins with the conceptual planning of closure, and ends with achieving a long-term stability of the site and establishing of the self-sustainable ecosystem. Applying of this concept is achieved an adequate conclusion in regard to the environment and thereby reducing the financial burden of the closure of mines process and its reclamation.

Strategy for the closure of mines is to be supported development of programs for the closure, by which to the mine and the surrounding area is returned sustainability, with action plans that include the scope of implementation funding.

Proper planning and measures for the mine closure are issues that need to be resolved by the mining sector of the state in compliance with international environmental standards such as ISO 14001 (Australian Government, Department of Industry, 2006), in order to:

- provide adequate resources to implement plans for the environment protection during operation and closure, and that
- plans for closure are designed with taking into account possible changes of geological and technological conditions on the site and community expectations.

The aim of establishing a strategic framework for mine closure is to promote nationally consistent approach for managing the closure at all levels of the state competence. Therefore, are established harmonized concepts for the mine closure, to can be applied with greater consistency with the development of legislation by the government and programme of the mining sector is required.

In planning the mine closure it is necessary to: protect human health and safety, to reduce or eliminate negative environmental impacts of exploitation, to enable

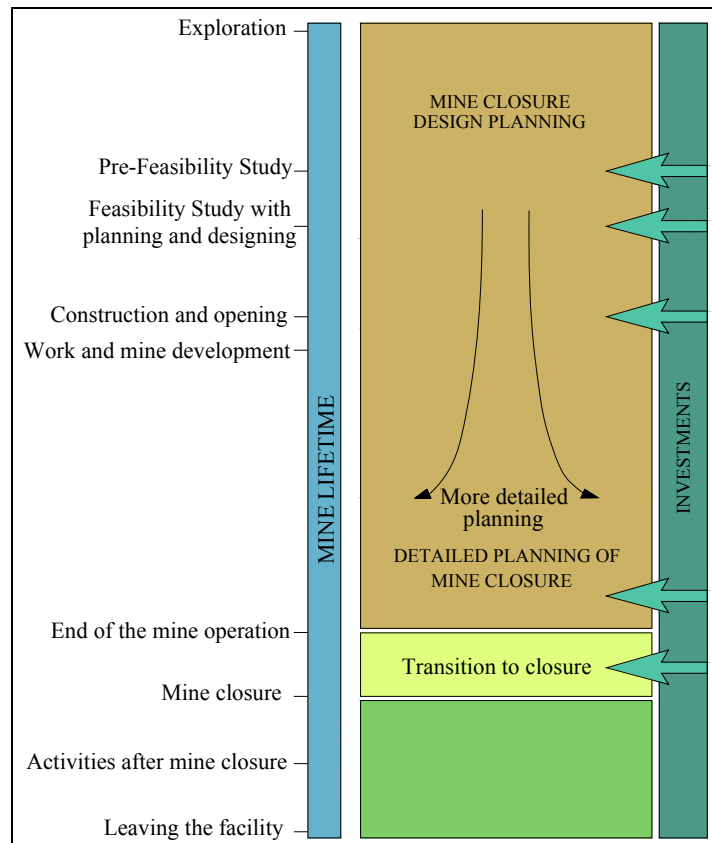
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the successful use of land and intensifying social and economic benefits during sustainable development and operation of the mine (ICMM, 2008). For the realization of the objectives of the closure of the mine is necessary to progressively reduce the risks caused by insufficient knowledge of the many influencing factors (Pavlović, 2002).

From the very beginning, the mine closure planning includes conceptual solutions becoming more detailed over the time (Figure 1).



**Figure 1** - Mine closure plan

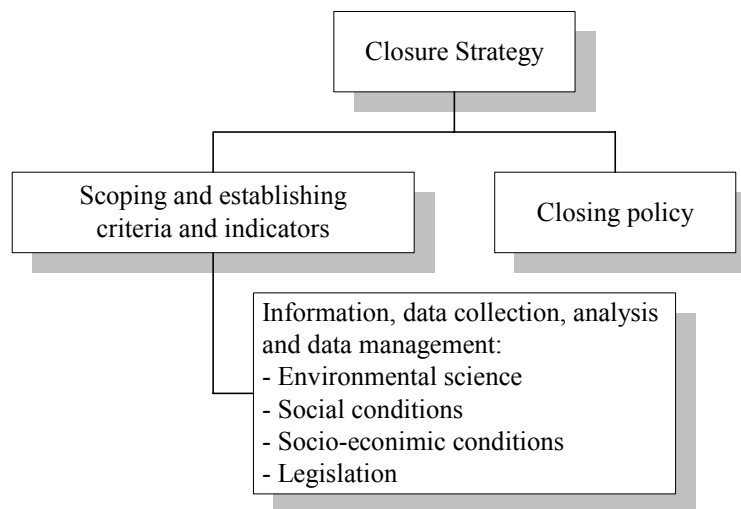
In the stage of conceptual decisions are to be set the general solutions and goals. During the detailed planning is to be made selection of the possible options for closing, determined the implementation methodology, defined monitoring and developed economic analysis.

## 2. MINE CLOSURE STRATEGY CONCEPT

Mine closure strategy includes a range of activities related to the mining of mineral resources. Exploration of deposit and processing of mineral resources with

supporting facilities are activities in the function of mining. Although in such a way set strategy is focused primarily on improving the activities in connection with the closing of the active mines, the principles are the same when in question are temporary closed or abandoned mines.

The process of sustainable mine closure changes the long-term business strategies referring to risks and opportunities for development (Robertson & Shaw, 2009). Therefore, the closure of the mine should be seen as a part of an overall strategy for sustainable development of mining (Figure 2).



**Figure 2** - Mine closure strategy

Area reclamation policy is a set of major goals and rules set by the company to implement a sustainable process required for the closure of mining, with the necessary review of the situation and determination of criteria and indicators. To obtain the right information to make the best technical and social decisions in closure planning, it is necessary to thoroughly consider all economic, social and environmental conditions with respect to legislation.

In Serbia there are many areas of closed mines not being rehabilitated in compliance with the standards to be now considered as acceptable. However, currently it is much more important to direct activities at existing mines in order to reduce future issues to a minimum.

Mine closure strategy is based on the policy base and set of objectives and rules grouped into six key areas: participation of interested parties, planning, financial measures, implementation, standards and abandonment.

**Inclusion of stakeholders** is to enable for all interested parties respect of their interests during the process of closing. Identifying the key stakeholders and interested groups, and developing of good relations with them, is the basis for a successful process of closing. Identification is followed by the consultation as an interactive process involving all parties during the all phases of the mine operation. In addition,

the communication has to be coordinated and strategically targeted and should reflect the needs of stakeholders and interest groups.

The benefit due to the successful process of stakeholder's consultation is reflected through: improving of decisions in planning, greater employees' motivation, improving relationships with government, better acceptance of the closure, improving the public image and reputation of the company and helpfulness of the community for future mining suggestions.

**Planning** of mine closure should begin during the development of Pre-feasibility Study, design phase and permitting for the mine, with upgrade during the operation. The lack of a mine closure plan update can lead to serious environmental and economic consequences. Planning ensures that the process of closure is cost-effective and in due time.

As a planning rule, risk-based approach has to reduce costs and uncertainty. Current trends in closure planning involve technical review and risks analysis, as well as the costs compensation in terms of engineering and the environment.

Mine closure plans include all the parameters of the natural environment and the mining system, including geology, geo-engineering, hydrogeology, hydrology, geochemistry, biology, environmental science and social factors.

To verify the choice of options for mine closure plan, commonly are used risk pattern that allows relatively quick and easy way to identify the best alternative for multicriteria decision making issues. Patterns are formed as the ratio of the probability of risk occurrence and criteria to be considered in relation to the consequences.

The probability of risk occurrence for the most negative effects can be divided into five classes for the possible conditions of the system (Table 1). In addition, it can be distinguished two main groups of probability criteria which includes the endangerment of the safety and protection and environmental and community interests imperil. Number of classes and groups can be adjusted and optimized for each specific facility.

**Table 1 - Risk probabilities**

<b>Probability classes</b>	<b>Probabilities of risk occurrence due to security endangerment (number of events/year)</b>	<b>Probabilities of risk occurrence due to imperil of environment and community interests (number of events/year)</b>
Not likely (N)	< 0,01%	< 0,1%
Unlikely (M)	0,01 – 0,1%	0,1 – 1%
Medium likely (S)	0,1 – 1%	1 – 10%
Very likely (V)	1 – 10%	10 – 50%
Expected (O)	> 10%	> 50%

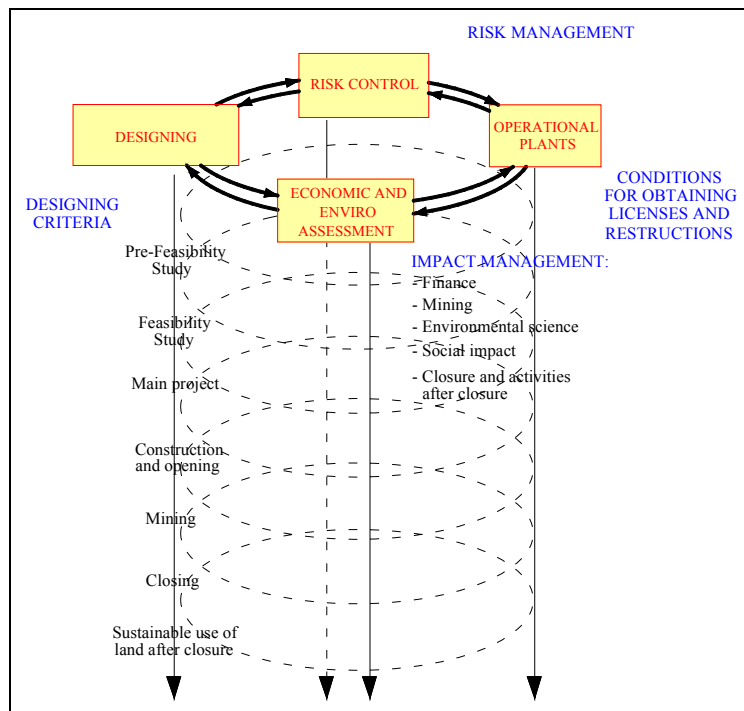
Requirements for the mine closure can set list of criteria, where the ranking according to the possible consequences from neglected up to the extreme can be conditional in the five levels, but also adjusted to a particular situation. Every type of planning is ranked from the best to the worst according to the evaluated risk indicators.

It is necessary to draw up plans for the closure that reflect the status of the project or business. During the lifetime of the mine, at least two types of closure plans are required: Conceptual closure plan (designing-feasibility stage) and the Main closure plan (phase of mining- mine opening, work and operations upon completion of work). Planning of closure is necessary to ensure the technical, environmental, economic and social feasibility.

The dynamics of closure planning requires regular review to reflect changing circumstances during the mine operation (Australian and New Zealand Minerals and Energy Council, Mineral Council of Australia, 2000). Closure plan should be modified in the event of any operational changes, new regulations or a new technology and should be comprehensively reviewed regularly. Typical cyclic planning and design phases during the mine lifetime are set out at Figure 3.

The wider objectives of mine closure planning are:

- environmental and public health and safety protection, with a safe and reliable closure practices;
- reduction or elimination of adverse impacts at the environmental when the mine ceases operations;
- establish of conditions that are consistent with pre-set targets for the final land use;
- reducing the need for the long-term monitoring and maintenance of the environment through the establishment of effective physical and chemical stability of the mine area.



**Figure 3** - Cyclic development of phase planning and design during the mine lifetime

**To financial measures** is necessary to ensure representation of closing costs within the financial statements of the company, which shows that the responsibility is not left to the community.

On the basis of the closure plan shall be made cost estimation for closure, to be reviewed regularly in order to comply with changes in the mining circumstances. Financial closure measures should reflect actual costs, and adequate safeguards should protect the community from the obligation during closing. Closure of the mine is usually done when there is no profit from the mining, and the remaining funds have only a small value. The aim of the implementation of financial measures is in the provision of adequate resources available at the end of the lifetime, to cover the often significant costs of mine closure.

Well-planned program includes closing phase of the planning and **implementation** phase. Coordination of these phases is provided by a well designed, systematic, safe and cost-effective closure of the mine. Thus, during the implementation, it is necessary to ensure the existence and identification of clear responsibilities and adequate resources to implement the closure plan, in order to ensure compliance with the closure plan, with adequate day to day management and supervision of conditions for closing implementation.

If inadequate measures are estimated for the fulfilment of obligations, resources must be provided from other sources. To these activities are prior the making of a business plan for closing, which provides the basis for implementing the closure plan. Development of a business plan provides the basis for measuring progress and highlights any necessary changes to the process of closing, including the schedule of activities, responsibilities, resources and deadlines. Therefore, implementation of the closure plan should reflect the status of the company operations.

**Standards** are provided for establishing of criteria to ensure that demonstrate successful completion of the closure, including the establishment of standards of business and the use of industry standards. In the interests of all stakeholders are to develop standards that are acceptable and achievable.

The final criterion which should be accomplished is specific for each closed mines, and reflects a unique set of environmental, social and economic circumstances. It is required to set a harmonized set of environmental indicators in order to clearly indicate the success of the field reclamation. As to achievement on an agreed end land use may be waited for years or even decades, it should also be develop a set of specific performance indicators to measure progress in meeting the final criteria. Properly selected, environmental indicators show whether the ecological processes that lead to a successful reclamation are moving toward the right direction. This allows timely intervention where trends are not positive. It should be made and agreed with stakeholders.

**Leaving** the area of the mine is carried out after reaching the final agreed criteria that meets the requirements of the responsible government body. For this reason, above all, is to be identified the responsible body mandated to make the final decision on accepting closure. After the final criteria met, the company can waive it interests.

When a responsible body agrees to leave the field by the company, management and maintenance of the field stays on the next holders of ownership rights or the state.

Successful closure may prevent certain improper land use after the mining. The company must recognize the condition of land, where the final criterion has not been realized due to damage to reclaimed fields and to prohibit it for the use either to the holders of ownership rights or to the local bodies. The failure of reclamation due to faulty land management practices by land users after the mining does not impose any retroactive liability of the mining company.

### 3. MINE CLOSURE OPTIONS

Closure of the mine can be planned, sudden or unplanned, and temporary closure.

**Planned closure** involves the preparation of Conceptual Closure Plan under which is performed the evaluation of closure plan in due time. The closure plan is based on the level of the existing bio-physical and socio-economic information and details on planning and development of the mine. As the project progresses, the Closure Plan is to be updated regularly and processes to reflect changes in the mine development, operational planning, and environmental conditions. The planned closure requires the preparation of the Plan for the cessation of the opencast mine operations a few years before closing, and systematic implementation of this plan.

In the event of **sudden and unplanned closure**, is implemented an accelerated process of closing. This includes immediate preparation and implementation of the Plan for the cessation (based on the already existing Closure Plan), taking into account non-operating status of the terrain. Where the calculated measures are inadequate to fund all requirements during the closure, the funds has been provided from other sources of the company.

As a result of economic or operational circumstances, it is possible to stop the mining, so mine is to be temporarily closed. **Temporary closure** of this nature is normally planned and assumed in terms of restarting of the mining. Control and maintenance process include immediate preparation and implementation of cessation plan, taking into account the potential for future operations in the field. It is recommended that, where it is feasible and economically reasonable, to carry out reclamation in all disturbed areas, even if it is unlikely that some of these areas are to remain undisturbed in the future. Field reclamation, and work to prevent potential contamination of the environment, should be implemented in accordance with the conception of the final closure. The temporary closure should always be a trigger for a review of the Final Closure Plan, which application is to be required if the circumstances are unfavourable for the re-opening.

### 4. CONCLUSION

In the interests of all stakeholders is to be involved in the process of mine closure, to ensure a balanced outcome and consideration of relevant issues.

For making tough decisions on the environment, taken in connection with the closure of the mine, it has to bear in mind that all stakeholders need access to quality, relevant and unbiased information based on solid scientific approach.

However, one should bear in mind that a complete scientific approach to the problem of security is not sufficient prerequisite for the adequate protection of the environment where there is a risk of serious side effects.

It is imperative that all stakeholders perceive the wider problem than the short-term profits and to implement comprehensive long-term strategic researches of the complex process for the mine closure.

Therefore, all stakeholders should freely and openly to perform compulsory verification of information and assumptions, and to conduct ongoing research in this area.

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