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Taking the risk out of a risky business: a land use approach to closure planning

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Abstract

Closure planning is an integral but sometimes forgotten aspect of life-of-mine planning. And for those mining houses that do put the required effort into formulating appropriate, practical closure objectives, these are often guided by environmental, social, financial and reputation-related risks to the company and are not necessarily the most suitable required end-state for the area. However, more and more emphasis is being placed on the need for dedicated, upfront land use planning to identify the most suitable post-mining end land use/s prior to the initiation of mining operations, as well as on the importance of this land use approach to the sustainability of the closure approach adopted.

Understanding the post-mining closure environment requires a good grasp on the end-state land use, which influences the formulation of closure objectives and associated measures, closure cost estimates as well as cost implications during the remaining operational phase and the direction of creative solutions, along with providing transparent commitment towards affected parties/stakeholders.

Furthermore, understanding the opportunities and constraints of the possible post-mining landscapes, whether they are environmentally and/or socially driven, empowers an operation to identify the most practical, cost-effective solutions for the post-mining landscape, most of which can be implemented during the operational phase, whilst creating opportunities for those communities remaining after final site relinquishment.

1 Introduction

1.1 Integrated thinking required

The most preferred end land use/s of a closed mine site are generally determined by a number of factors, including the current land use/s surrounding the site, the potential for beneficial reuse of surface infrastructure, the extent of environmental impacts resulting from the operational period and future planning objectives by local regulators. Other considerations may include the need to safeguard against physical, chemical and biological hazards; zoning bylaws and real estate value; and regulatory standards (Mchaina, 2001). Ultimately, the goal should be reinstatement of a functional end land use that can positively contribute towards the biophysical and societal demands of the people and/or animals living in proximity to the site.

Understanding the opportunities and constraints of the possible post-mining landscapes, whether they are environmentally and/or socially driven, empowers an operation to identify the most practical, cost-effective solutions for the post-mining landscape, most of which can be implemented during the operational phase, whilst creating opportunities for those communities remaining after final site relinquishment.

Determining the most appropriate end land use/s requires focus on at least the following key elements:

- Mining method.
- Mechanisms for material movement as well as techniques to optimise this movement.

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- Manner in which topsoil / growth medium is stripped and stockpiled for later reuse.
- Required land capability needed to recreate the desired end land use/s.
- Possible long-term water management needing to be put in place.
- Location of the operation in proximity to other industrial and/or urban hubs.
- Operation-related infrastructure and/or services with a possible beneficial post-mining reuse value.
- Stakeholder expectations – particularly important in communities dependant on the mining operation.

Taking the above into consideration in life-of-mine planning enables balancing of mining-related risks with the foreseen capabilities of the post-mining landscape.

1.2 Guiding principles for land use planning

The following guiding principles, all of which require an overarching regional perspective that considers the needs for long-term, sustainable and functional landscapes, have been identified as being key in determining the most appropriate end land use/s for rehabilitation of disturbed areas:

- Understanding the need for 'food security' within the area, which would result in the reinstatement of productive, agriculturally based land use/s.
- Understanding the drivers for long-term water conservation, requiring consideration of treatment options/alternatives, towards positively contributing to long-term local catchment integrity.
- Understanding the supply and demand on local ecosystem services, whether they are ecologically and/or societally driven, aiming for a no net loss of these services.
- Understanding the underpinning macro-economy and socio-cultural context of the rehabilitated environment, towards creation of post-mining industries that could replace or enhance the mining/industry economic contribution and societal functionality within the area.
- Understanding the financial implications of reinstating particular end land uses for both the companies required to rehabilitate as well as the third parties responsible for care and maintenance of the rehabilitated landscapes.

Consideration of the above would help towards recreating post-mining landscapes that contribute towards the long-term safety, health, function and viability of the affected communities and environments by:

- Minimising costs, but not at the expense of meeting the other long-term objectives.
- Minimising pollution.
- Remediating degraded areas, polluted soils and water.
- Establishing sustainable ecosystems.
- Maximising the use of existing structures and infrastructure for future economic benefit.
- Providing a safe environment.
- Facilitating sustainable livelihoods of affected communities, in accordance with corporate social responsibility targets and local and regional integrated development planning.

2 Integrating closure planning and end-land-use planning

2.1 Land use planning with closure in mind

Closure planning is an integral but sometimes forgotten aspect of life-of-mine planning. And for those mining houses that do put the required effort into formulating appropriate, practical closure objectives, these are often guided by environmental, social, financial and reputation-related risks to the company and not necessarily the most suitable required end state for the area. However, more and more emphasis is being placed on the need for dedicated, upfront land use planning to identify the most suitable post-mining end land use/s prior to initiation of mining operations, as well as on the importance of this land use approach to the sustainability of the closure approach adopted.

Understanding the post-mining closure environment requires a good grasp on the end state land use, which influences formulation of closure objectives and associated measures, closure cost estimates as well as cost implications during the remaining operational phase and the direction of creative solutions, along with providing transparent commitment towards affected parties/stakeholders.

2.2 Risks of not planning for a positive post-mining legacy

2.2.1 Shortsighted, uncoordinated operational approach

The most obvious form of landscape transformation associated with mining is an alteration in the topography of the mined area. As a consequence of the huge scale of earth removal and relocation that occurs during surface mining, the first step in attempting to restore the area to its natural state is to landscape the topography so that it matches or at least approximates that of the surrounding areas (Carrick and Krűger, 2007). However, this aim is often negated due to poor operational materials movement planning that is driven by economic and logistical considerations only and does not adequately consider final location or placement requirements of the material. The result in such instances is that final landforms are often harsh and unnatural in appearance and may also result in long-term surface water runoff problems. This is especially true for old mines with a long operational legacy, where production drove mining methods and where planning for a functional post-mining landscape was not even a consideration.

Tailings dams and waste material dumps are often the most visual long-term legacy of mines, and their location, footprint and profile are key aspects that need to be taken into consideration at the planning stage of a new mine. Although primarily driven by ecological, spatial, operational and cost implications, it is crucial that their final integration into the surrounding landscape be considered from the onset of mining, as failure to do so may impact potential end uses of areas surrounding the dumps, as well as of the dumps themselves. Dumps with less steep side slopes and concave-convex profile resembling natural landforms may facilitate a greater number of end uses and relate better with the surrounding landscape. However, such landforms may depend on the availability of larger footprint areas and ultimately require better mine planning so that material is correctly positioned from the start of the mining activity (Hancock et al., 2003).

Removal, storage and reapplication of topsoil and growth medium is another operational aspect that requires a coordinated approach, as failure to do so may eliminate or greatly reduce many post-mining land uses (Limpitlaw et al., 2005). When stripped topsoil is stored for too long, the likelihood of crop reestablishment on rehabilitated areas is greatly reduced, due to the poor aeration of such soils. However, soil that is moved and placed when wet compacts more readily and creates unfavourable conditions for plant root establishment. Traversing recently rehabilitated areas with heavy machinery, which often happens when operational and rehabilitation scheduling are not adequately aligned, further exacerbates these problems. Furthermore, although opportunities exist for the use of alternative sources of growth medium (waste rock, discard, sub-soils, etc.), suitable characterisation of this material is often not undertaken or fully understood towards determining more appropriate and/or alternative options for rehabilitation.

When the above is coupled with a growth medium deficit to begin with, it becomes evident that failure to adequately address this aspect throughout operations may seriously limited the end-use potential of mined area. Hence, priority soil application areas aligned to rehabilitation requirements, the likelihood of re-cultivation and other future land uses should be identified in order to ensure that potentially productive soil is not wasted as the result of 'indiscriminate' application.

2.2.2 Unmitigated biophysical impacts and associated risks

If left unmitigated, previously mined areas can pose a number of long-term risks that can also be restrictive in terms of potential end land uses. Obvious examples relate to potentially unsafe conditions associated with underground mining and unstable landforms and slopes. In this manner, the potential restrictive implications of undermined areas in terms of end land uses must be considered from the onset of mining and mitigated where possible. Large-scale surface subsidence and the resultant topographical alterations may give rise to considerable surface water drainage and ponding problems and may pose long-term safety concerns that will likely need to be addressed in order to allow beneficial future use of the land. Similarly, the structural stability and erodibility of backfilled open pit mining areas and rehabilitated dumps may in some instances also limit certain land uses and preclude public access.

However, risks arising from post-closure management of previously mined areas also need to be considered. For example, remaining mineral reserves are often illegally re-accessed by artisanal miners after a mine has closed, which may lead to dangerous or even fatal conditions. Rehabilitated mine areas are also sometimes inappropriately utilised by farmers, who heavily overgraze the land and then blame the mine in an attempt to access government compensation (Limpitlaw et al., 2005). This type of misuse is commonly associated with rehabilitated land that is leased out, illustrating a typical case of the 'tragedy of the commons'. Inappropriate use of previously mined areas may also result in water pollution, the large-scale infestation of alien invader plant species or even highly dangerous conditions such as spontaneous combustion at old coal mines.

The environmental risks associated with post-mining areas and landforms therefore need to be addressed throughout operations, with a view of their future use after mine closure, and must be balanced against potential economic and social benefits. Nevertheless, beneficial end uses are unlikely to be without environmental impacts, and a proper consideration of the total benefit to the community should also include an assessment of the associated risks (Doupé and Lymbery, 2005). Where identified risks to the public or the environment outweigh the potential benefits, such areas should be isolated and made as safe as possible and their further use precluded until such time that the risks can be mitigated, if feasible.

2.2.3 Reduced 'social licence to operate'

During the 1990s, the importance of understanding and mitigating the effects of environmental impacts of mining started coming to the forefront of mine planning. Prior to this, mining focus was predominantly on production, with little consideration for the need to reinstate a functional post-mining landscape.

As the world moves into the twenty-first century, increasing pressure is being placed on companies to provide, prior to receipt of mining rights, detailed plans on how they will contribute towards leaving behind a positive post-mining legacy for the surrounding communities and/or host governments.

The current increasing trend in resource nationalism seen across the world could prove to be a driving consideration when formulating appropriate closure objectives for mining operations. The level of closure planning is often underpinned by the sophistication of the mining house, with many international players looking to guidelines and standards such as the International Finance Corporation, International Council on Mining and Metals and local regulations to set the baseline for closure requirements. However, to date closure planning has focussed predominantly on the physical and biophysical environmental components of the closure, with socio-economic aspects briefly touched on in required social and labour plans or associated documents. Although community expectations of beneficial post-mining end uses are often high and may need to be tempered by discussion and examination of the economic and environmental

consequences of various closure options, given the current political attention on the need to improve the overall socio-economic conditions in the countries, this closure planning focus will need to change substantially towards ensuring planning incorporates key elements for the creation of a beneficial, post-mining positive closure legacy.

Hence, it is essential that planning for mine closure involves dialogue with all relevant stakeholder groups, including government agencies and mining communities – a process aimed at securing a 'social licence to mine' (Evans, 2006).

2.2.4 Limited time for appropriate planning and implementation

Warhurst and Noronha (2000) noted that the attractiveness of the concept of planning for closure as a whole life-cycle approach to managing mining-related environmental impacts from project conceptualisation through operations to closure is rooted in what may be referred to as the time factor. The greater the time lapse between the occurrence of environmental damage and its remediation, the greater (in most cases) will be the resources (both human and financial) needed to address the problem. In the absence of adequate closure planning, the demand for financial resources to complete the closure process will occur at a time when the firm is experiencing a reduction in cash flows.

2.2.5 Unscheduled closure of operations

Stacey et al. (2010) contend that final land use planning must evolve throughout the life of the mine and needs to be reviewed to fit within developmental, ecological, social and political imperatives as these change. Furthermore, valid closure goals can be set only in full consultation with those affected by the operation.

The relevance of this approach becomes especially evident in the event of unscheduled mine closure, as the ability of the mine to achieve a more desirable end state will already have been secured during operations. During unscheduled mine closure, it stands to reason that most decisions need to be taken and executed rapidly, which leaves little 'manoeuvring room' to accommodate potential end land uses that have not been anticipated and planned for upfront.

2.2.6 Financial and reputational risks

Mining methods, minerals processing and management technologies have developed to a high level of sophistication and efficiency, however it is often possible to reduce environmental impacts through the implementation of relatively simple and low-cost scientific and engineering technologies during the initial stages of project construction. Conversely, the cost of retroactive installation of environmental control technologies at later stages in the project life cycle is likely to be prohibitive (Morrey, 1999).

The same principle holds true in terms of end land uses, as the financial cost of 'back-engineering' in order to facilitate or enable certain land uses late in the life cycle of a mine are likely to be exorbitant in most cases. Failure to adequately consider post-closure land uses during initial planning may therefore hold serious financial repercussions for mines, all the more so in instances where negative press coverage and public dissatisfaction resulting from undesirable long-term conditions arise.

2.3 Opportunities for end-land-use planning

2.3.1 Beneficial reuse of infrastructure

Most mining assets, due to their highly specialised nature, are not often viewed as potential non-mining assets in a broader context and are therefore seldom retained or transferred to a third party for beneficial reuse (Murphy et al., 2007). However reusing mining assets, either in-situ or elsewhere, has a number of inherent advantages. The cost of establishing new industries and land use activities may be partially or even largely avoided, as future users utilise what is already there. The use of large amounts of raw material and the environmental impacts associated therewith is also eliminated. Furthermore, this approach helps to

retain the visual character and 'sense of place' of an area by allowing the 'temporal layering' of the cultural landscape to occur, as opposed to a 'clean slate' approach that effectively removes most traces of previous land uses.

In adopting an alternative use strategy, the suitability of the mine plant and infrastructure in terms of its age, location, and specific characteristics need to be considered. This would include assessing the suitability for use and safety, the potential for environmental impact and the associated cost of retrofitting the specific mining assets for future use. While it would generally be considered that asset transfer would be a low-cost option, it is likely that not all assets will be fit for a purpose, and some expenditure will be required to either renovate or refurbish the asset prior to transfer. In this regard, the possibility of future mining/re-processing opportunities on-site and in the greater region and the possible extended use of existing infrastructure must also be considered.

Hence, in instances where potential post-mining uses of mining infrastructure are identified up front, some of the associated costs may already be 'built-in' with the initial design of the infrastructure, thereby partially eliminating potentially prohibitive costs at a later stage, when the mine is already having to fork out large amounts of money in other areas of closure-related work. If future end uses of mine infrastructure are identified during mine planning, the potential to develop these after mine closure can be secured through appropriate and consultative planning, whereas their beneficial reuse after mine closure may be precluded if this is not done, simply because of the way in which plant and infrastructure elements are spatially positioned in relation to each other and surrounding land uses.

Critical to the success of such ownership transfer are the appropriate due diligence assessment and understanding of potential environmental and health liabilities. In the case of new mines or mines that are planning to expand, it is therefore a useful approach to identify potential buyers or beneficiaries and forge agreements for asset transfer at an early stage rather than having to search for potential end users near the end of the life of the mine, which may give rise to legal, financial and logistic requirements making the reuse of infrastructure ultimately unfeasible.

2.3.2 Enhancement of ecological goods and services through ecosystem functionality

By reinstating functional ecosystems, such as wetlands and wilderness habitats, a number of obvious functions are served, such as providing feeding, breeding and nesting areas for fauna and creating potential conservation areas for threatened species. However, the concept of 'environmental economics' is fast gaining ground, as the highly valuable range of goods and services that functional ecosystems deliver is being increasingly acknowledged. Other inherent functions of such areas such as flood attenuation, carbon sequestration, water filtration and purification have a measurable monetary value and the need to protect and where possible reinstate these functions is being increasingly acknowledged and should form an integral part of post-closure land use planning.

2.3.3 Creation of sustainable livelihoods

The recultivation of mining sites has been and is still used extensively as a means of reestablishing livelihoods after mine closure throughout the world (Schulz and Wiegleb, 2000), in part due to the fact that many mines are located in agricultural areas to begin with. However it is becoming increasingly evident that the pre-mining land capability can seldom be fully reinstated and as a consequence leads to reduced production levels and decreased livelihood support. Furthermore, in general it appears that areas with greater wealth and more diversified economies are able to absorb the shock of mine closure more effectively than poorer areas and/or those with less diversified economies (Andrews-Speed et al., 2005). Hence, it is becoming necessary to explore alternate ways of sustaining the affected communities in post-mining regions, especially in the face of increased pressure to ensure long-term food security globally. This has led to the exploration of creative ways of producing the same amount of food from less land or from less productive land than what was available before the onset of mining.

In order to identify possible alternative livelihoods that are functional, practical and sustainable, the following aspects could be considered as part of mine closure planning:

- Conducting land use planning to optimise use of local natural resources, existing facilities and/or infrastructure, towards creating a 'substitution economy' to ensure post-mining community sustainability.
- Identifying measures to establish an appropriate institutional and organisational base, including capacity building of local government structures and/or third parties to take over infrastructure and related services.
- Engaging with communities/stakeholders throughout operations to facilitate a consultative process to develop and build consensus concerning an overall strategy to establish a diversified sustainable local economy and to identify projects (agriculture, health, small and medium enterprises, etc.) that can be implemented and become entrenched before mining moves away from the area.
- Developing mine employee training programs aimed at multiskilling and eventual transfer of skills to other livelihood and economic activities post-mining.
- Implementing measures to improve the skills base of the local community and develop alternate livelihood activities that are sustainable beyond the life of mine.

Undoubtedly, with current political attention on the need to improve the overall socio-economic conditions in host countries, closure planning focus will need to focus more emphatically on ensuring that planning incorporates key elements for creation of a beneficial, post-mining positive closure legacy.

2.3.4 Recreation of 'out-the-box', practical post-mining uses

Mine closure and end-use planning is increasingly becoming a multi-disciplinary approach, which is laying the foundations for continued innovation and exploration of new ideas. Hence, the process is no longer dictated by engineering requirements and ecological parameters only, but often involves many other disciplines, including stakeholder engagement and social scientists, town planners and landscape architects.

The novelty factor in identification of post-closure land uses must also never be discounted, as sometimes seemingly outlandish proposals can create vibrant end landscapes that would otherwise have fallen into or remained in disuse. The book 101 Things to Do with a Hole in the Ground by Georgina Pearman (2009), published by the Post-Mining Alliance in association with the Eden Project, provides international successful, practical examples of recreated post-mining land uses that have often been generated from 'out-the-box' concepts but that, with good planning, have proved to be highly successful.

2.3.5 Allowance for reinstatement of regional footprints

Possibly one of the most exciting opportunities for upfront land use planning in disturbed areas is the ability to reinstate significantly large functional areas when considering the planning from a regional perspective. Many large mining houses cover expansive footprint areas and/or consist of numerous operations that occur within one area/region. These are often interspersed/interlinked with similar other operations that face similar challenges, impacts and residual risks.

These 'regional linkages' provide an opportunity for dedicated end land use and mine closure planning over much larger scales, enabling possible mitigation of cumulative environmental and social impacts in a focussed, co-ordinated manner. Furthermore, they provide an opportunity for integrated management/ conservation of 'sensitive' social, ecological and economic communities from an overarching perspective that could result not only in mitigation of ecological habitat fragmentation/corridor creation but also reinstatement of larger expanses of functional agricultural/farming land and the possible development of human settlement/enhancement towards creating identified post-mining sustainable livelihoods.

2.4 Framework for land use planning

In order to mitigate/limit the afore-mentioned risks and enhance the opportunities, a post-mining land use plan should be compiled, prior and/or parallel to formulation of closure objectives, considering at least the following:

- Site context and sensitivity related to the areas that are available for post-mine closure utilisation and those areas that are sensitive, requiring protection.
- Key existing services and infrastructure that need to be considered with the land use planning.
- Inventory of surface infrastructure, indicating those that could be beneficially reused and those that need to be demolished, dismantled and/or removed.
- Opportunities and constraints, typically addressing threats like areas of pollution and opportunities such as riverine areas for recreation.
- Land use schedule and inventory of possible suitable land uses as well as the suitability of those areas for development.
- Access and bulk services required to support each of the identified land uses – i.e., indicate roads and services that are available to support the identified land use options.
- Prioritisation and ranking of the candidate land uses and clustering of these in appropriate land use mixes.
- Outcome of consultation with stakeholders and the refinement of the land use options based on this consultation.
- Final zonation and layout based on the outcome of the stakeholder consultation and the presentation of these zoned land uses on suitable layout maps.
- Control and intervention measures required to aid with the sustainability of each land use and demarcated area.
- Schedule and process for monitoring, evaluation and possible revision or update of the land uses.
- Action plan reflecting timing, costing, resources and responsibilities.

3 Towards regional mine closure and end-land-use planning

In general terms, mine rehabilitation is usually aimed at ensuring that the final land use and morphological character of the site are compatible with either the current state of the surrounding area or with that of the pre-mining environment (Soltanmohammadi et al., 2010). However, as increasingly large areas are being transformed by mining, especially in mining belt areas characterised by extensive mineral deposits, the pre-mining environment is becoming difficult or even impossible to achieve in such areas. Hence, it is essential that mine closure and ultimately end-use planning of these areas be approached from an overarching, regional perspective to ensure that proper integration and seamless transition of various mined-out areas into the surrounding landscape fabric is achieved.

Changes over time of especially the socio-political context must also be anticipated and accounted for, as long-term planning requirements in this regard are also likely to change over time. Furthermore, the establishment of regional land use planning strategies supported by local and district municipalities as well as all major mines in a region should be pursued to ensure that all role players strive towards an aligned long-term land use vision for the region. Individual mine land use plans would then inform and form part of the land use master plan for the region.

4 Conclusion

Understanding that closure planning can actually have positive benefits for both the mine and surrounding communities should provide the principal rationale for forward planning, within the context of evolving frameworks of legislation that increasingly requires companies to take responsibility for cleaning up their environmental impacts from the exploration stage through operations to post-closure.

The compilation of a suitable closure plan in the upfront mine planning stages of an operation, incorporating defined end-land-use objectives, is imperative in identification of appropriate biophysical and socio-economic post-mining goals that could be agreed with regulators. This would greatly assist towards limiting/mitigating mining-related environmental impacts in a timely manner, reinstating practical, defensible post-mining land uses, developing local skills, creating job opportunities and enhancing long-term post-mining sustainable livelihoods, thereby counteracting the effects of possible future political and/or environmental debates that could ultimately end in unscheduled closure of an operation.

Furthermore, understanding the opportunities and constraints of the possible post-mining landscapes, whether they are environmentally and/or socially driven, empowers an operation to identify the most practical, cost-effective solutions for the post-mining landscape, most of which can be implemented during the operational phase, whilst creating opportunities for communities remaining after final site relinquishment.

Ultimately, ensuring upfront closure planning, guided by defined end-land-use planning, just makes sound business sense.

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