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Uranium-REE Keynote

ENVIRONMENTAL AND SOCIAL ASPECTS OF FEASIBILITY STUDIES, MINING OPERATIONS AND CLOSURE; BALANCING REALITIES AND EXPECTATIONS FROM DIFFERENT ANGLES

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ABSTRACT

The mining industry itself and government bodies have long recognized the importance of environmental and social aspects of mining, especially over the last three or four decades. These aspects must be considered from the earliest stages of exploration, and importantly through project definition, pre-feasibility and feasibility studies. Otherwise promising projects have been delayed or cancelled due to social and environmental concerns, both real but also perceived. Conversely, a socially and governmentally supported project, meeting all necessary environmental aspects, should not proceed without a genuine orebody and sufficient knowledge that it can be mined, processed and sold economically for an acceptable income to the miner, government and community. Some projects start poorly on environmental and social aspects; they must then fight to gain trust and counteract adverse aspects of their environmental and social impacts, real and perceived. How much better is it to get off to a good start, maintain it and end with a closure acceptable to all?

This is, of course, easier said than done. This paper looks at incorporating environmental and social aspects into mining projects from planning through operations to closure, and in particular the 'mainstreaming' of these aspects, rather than as an add-on or merely a publicity exercise. After a general and international introduction the emphasis will be on the environmental and social aspects of planning and feasibility. Another emphasis is on uranium mining, which both is and is not 'just mining', but the principles have broad application.

INTRODUCTION

Why Consider Environmental and Social Aspects in Mining?

These, sometimes called 'soft' aspects of a mining project, are ignored at one's peril, but this is hardly disputed any more. Regarding social aspects, recall that mining does not exist for its own sake, but rather to supply raw materials for society at large. However, by social aspects here I refer more to the society and people in a mine's vicinity and the government (nation, state, province, district, prefecture…) in which a mine is to be found. It includes regulatory and governmental aspects, but especially includes relationships with neighbours and civil organizations.

The environment is not only the natural environment – plant, animals, water, soil and air – but also agricultural or pastoral pursuits. It is often extended to include humans, particularly for health aspects, overlapping into social aspects.

Both aspects include a moral aspect, considering human rights, people's attachment and affinity to land, and our responsibility to future generations and to the natural systems that, in the end, support all life on Earth.

In short, good-functioning social relationships and environmental protection and responsibility are a big plus for a mining project at all stages of its existence. Conversely, poor social relationships can lead to the refusal of approvals and even civil unrest and early shutdown, and poor environmental performance is frequently followed by a loss of governmental support for that individual project, with possible shutdown, and a loss of societal trust for the whole mining industry.

Trends

A growing emphasis by the mining industry itself and associated government bodies on the importance of environmental and social aspects of mining has been apparent, especially over the last three or four decades. To many commentators, certainly from within the mining industry, the handling of environmental and social aspects of mining has, in general, improved over this time, and much more emphasis is placed on them by regulators, governments at all levels, interest groups and individuals. This improvement is no doubt real, but exceptions occur and criticism of the mining industry for these is ongoing, so there is no room for complacency.

An encouraging trend is the 'mainstreaming' of the environmental and social aspects of mining, in all its stages. In theory and in practice, they are increasingly becoming a standard part of planning, regulating, mining and milling of uranium. Many operational personnel and managers now have an appreciation of the importance of these aspects. At the same time, environmental and social specialists are more effective when they have an appreciation of the technical and financial aspects of mining projects. No-one can really be an expert in all the areas required by modern mining, but proponents will gain by having a level of awareness and a willingness to seek more expert opinion and input. This is best obtained from environmental and social experts who, in turn, have an appreciation of the technological and financial realities faced by any mining project at every stage.

THE PLAYERS – 'STAKEHOLDERS'

Definitions of 'stakeholders vary, and in it broadest sense it means anyone (person or organization) that is directly involved in a project or directly affected by it. It is usually extended to include others not so directly involved but having an interest, be that largely pro (such as a mining association or a chamber of industry), anti (some 'green' lobby groups or other non-government organizations (NGOs)), or those seeking their best interests, such as local communities seeking employment or maximal compensation.

The first player is the proponent, the organization (or sometimes, at least in the beginning, an individual or partnership) controlling the exploration, mining and milling or remediation activity. This may be a government department or a government-owned company. The second is typically the regulator – or rather, the group of regulators – from whom the appropriate legal tenure and formal approvals must be obtained, and to whom regular reports and perhaps payments are due. These may exist at more than one level of government, e.g. both state/provincial and national.

A typical stakeholders list may include:

- The proponent;
  - owners, management, workers, and sometimes workers' industrial unions
- Local;
  - Local government, formal or informal
  - Inhabitants, both direct beneficiaries and non-beneficiaries, and especially those who's land and livelihood is affected
  - Businesses, business groups, indigenous people's or other landholders' groups, civil or religious groups, local media
- Regional;
  - Regional (e.g. state, province) government especially regulators – often several regulating groups
  - Regional indigenous peoples' groups
  - Inhabitants of nearby regions, especially if a source of workers and services
  - Regional or city-based NGOs, industry and lobby groups, regional media
- National;
  - National governments, especially regulators
  - National industry groups
  - National NGOs, industry and lobby groups, national media
- International;
  - Other countries if cross-boundary transport, sourcing of workers, goods or services are involved
  - The keepers of international agreements honoured by host or customer countries
    - These can include voluntary codes of conduct of international industry groups, or legally binding agreements such as about migration of wildlife or pastoral stock, cross-border water sharing or nuclear safeguards.

Some might claim that the environment itself is a stakeholder, for its own sake or for the sake of ecosystem services, but for our purposes we will assume this is covered by the proponents and other stakeholders such as regulators and NGOs.

Working out who the relevant stakeholders are, and the extent to which their opinion needs to be taken into account, is not always straightforward but is a reality that all projects face.

COMMENTARY AND GUIDANCE

International Guidance (Uranium Mining)

Mining regulation is a matter for individual countries. However, many mining companies operate across more than one country and some across the world. A selection of emerging international guidelines is presented here, with an emphasis on uranium mining. Although some comments are offered, they are the author's and the IAEA does not have any recommendation, good or bad, on these examples; there are other examples that may be relevant to individual projects. A miner and regulator should always consider what is appropriate for the individual country and project. Guidelines in individual countries or provinces/states of countries may also provide guidance.

International Atomic Energy Agency

The motto of the International Atomic Energy Agency (IAEA) is 'atoms for peace'. The Uranium Production Cycle, including exploration, mining and processing of the raw materials for nuclear power is one of the themes where the IAEA is active in promoting best practice. This extends to the eventual decommissioning and remediation of mining and processing facilities, and where required, to the remediation of legacy sites left from earlier styles of mining.

In particular, interest and expertise in these matters at the IAEA is contained in two of its Divisions:

- Nuclear Fuel Cycle and Waste Technology Division – 'the technologists';
- Radiation Transport and Waste Safety Division – 'safety and regulatory guidance'.

Other parts of the IAEA are also involved, including the Department of Safeguards (who inspect security and safeguards aspects of uranium mines on the ground, as well as their better-known work with uranium enrichment facilities and nuclear power plants), and parts of the Department of Nuclear Sciences and Application. Each year the IAEA organises or participates in many activities supporting the Uranium Production Cycle[(1)]. Some of its publications and activities are described below.

Nearly all environmental aspects of uranium mining are also relevant for other commodities, although special emphasis is put on radiological protection in the case of uranium. At the same time, naturally occurring radioactive materials (NORMs) are relevant in many other industries, notably thorium and mineral sands mining and the oil and gas industry. Perhaps because of the additional factor of radiation protection, in some countries the general environmental protection requirements for uranium mining are, or were, stricter than requirements for other mining and as a result were sometimes developed earlier than for other mines. Hence guidelines prepared for uranium mining have broader application, and are worth consulting for other types of mining.

Best Practice in Environmental Management of Uranium Mining

In 2010 the IAEA published 'Best Practice in Environmental Management of Uranium Mining'[(2)]. This document may be freely downloaded from the internet. It has four sections summarized below.

Introduction

This section gives the background to the applicability of best practice to uranium mining. By identifying, understanding, managing and minimizing potential adverse impacts, key benefits are:

- Improved environmental management;
- Improved socioeconomic outcomes;
- Demonstrated good corporate governance and accountability;
- Improved liability management;
- Improved quality control;
- Reduced operational costs and increased profitability.

Guiding Principles

The basic guiding principles are based on those of sustainable development. Specifically, at least the following three should be considered:

- Sustainable development;
    - Balancing environmental, social, economic and governance issues
    - Based on the Brundtland Report definition[(3)], meeting the needs of the present without compromising the ability of future generations to meet their own needs
- ALARA – As Low As Reasonably Achievable;
    - Originally developed for worker radiation protection, where risks are kept as low as reasonably achievable with social and economic factors being taken into account.
    - There are also absolute upper limits for workers
    - This does not mandate zero impacts or necessarily as low as technologically achievable with an unlimited budget
    - Whilst not specifically stated in the document, environmental and other impacts could also be considered under the ALARA principle
- Precautionary principle;
    - Requires the anticipation, prevention and correction of the causes of environmental degradation
    - The lack of full scientific certainty should not be used to postpone preventative measures
    - Again, there is consideration of environmental, social, economic and governance issues.

Best Practice Application

The application of best practice principles for a project begins at the conceptual phase and continues through all of the stages of the project. For mining, the phases are typically:

- Exploration/conceptual design;
- Feasibility studies;
- Construction;
- Operation;
- Remediation;
- Closure and post-closure stewardship.

It should be recognized that some mines may have long or short times between these phases, or may cease operations for months or even years at times before reopening. Practical aspects include:

- Exploration/conceptual design;
    - Baseline data collection
    - Environmental
    - Social/Economic
- Public/Stakeholder involvement;
    - Identification of relevant people and organisations including government at all relevant levels
    - Preparedness of the project owners, private or government, to listen to the issues raised and genuinely seek to address them.

Whilst this last aspect takes time and effort, there are many cases where a technically, economically and even environmentally sound project has failed to get started or has suffered major difficulties or even closure due to lack of appropriate stakeholder involvement.

Associated with public and stakeholder involvement is typically an impact assessment stage. In this, the hazards and risks associated with a project are studied, understood and assessed. If the expected impacts are understood and acceptable with appropriate management, that aspect is considered acceptable. If the hazard and risks of an aspect of a project are not acceptable, the design or the management procedures should be modified to reduce the impact to something that is acceptable.

All of these aspects form part of a project's 'social licence to operate'; i.e. its overall acceptance by the people around, and others, that it is a worthwhile project and should proceed (or continue).
Before a project is constructed, plans should be prepared for normal operations including waste management and monitoring. Contingency plans should also be prepared in case something goes wrong and impacts become or are becoming unacceptable.

Note that environmental or health monitoring in itself is not environmental protection. Rather, it informs the operator and stakeholders of the status of the environment and any trends that may be occurring. If problems occur, action should be taken; further monitoring will confirm if conditions are returning to an acceptable state or if additional action is required.

Other Relevant IAEA Activities and Publications

The IAEA provides a large amount of information relevant to radiation protection in all mining, oil and gas and related industries. These are organised in a hierarchy. The Basic Safety Standard[(4)] is the lead document and is available in all official IAEA languages. It was last revised in 2011 following extensive consultation across the world.

Other types of documents that include material relevant to mining are:

- Safety Series;
- Safety Standards Series;

- Safety Reports Series;
- Technical Reports Series (including the Nuclear Energy Series);
- Tecdoc Series (Technical Documents);
- Training Course Series;
- Proceedings Series.

Earlier publications regarding general environmental and social aspects of uranium mining include:

- Establishment of uranium mining and processing operations in the context of sustainable development[5];
- Guidebook on environmental impact assessment for in situ leach mining projects[6];
- Guidebook on good practice in the management of uranium mining and mill operations and the preparation for their closure[7];
- Environmental impact assessment for uranium mine, mill and in situ leach projects[8];
- Guidebook on the development of regulations for uranium deposit development and production[9].

The IAEA has also organised a number of relevant conferences and open technical meetings over the last three decades that include the subject. It has undertaken and continues to undertake many Technical Cooperation projects in less-developed member states, including projects regarding uranium mining and legacy site remediation. Symposia, conferences and technical meetings are also undertaken, often with published proceedings.

Information exchanges using the modern medium of the internet are also hosted by the IAEA. One relevant forum is ENVIRONET, which aims to provide support and information exchange related to environmental management and remediation of radiologically contaminated sites including mines[10]. ENVIRONET also maintains a 'LinkedIn' account.

World Nuclear Association

The World Nuclear Association is an international organization that promotes nuclear energy and supports the many companies that comprise the global nuclear industry. It developed from the Uranium Institute, established in London in 1975. As of early 2015, WNA stated that its current members were responsible for virtually all of world uranium, conversion, and enrichment production and most of the world's nuclear-generated electricity[11].

The WNA launched a policy document 'Sustaining Global Best Practices in Uranium Mining and Processing, Principles for Managing Radiation, Health and Safety, Waste and Environment'[12] in 2008. This document was an outgrowth of an IAEA cooperation project that closely involved industry and governmental experts in uranium mining from around the world[13], and whose principles are in general supported by the IAEA. The WNA policy refers to the WNA Charter of Ethics, required of its members, and its Principles of Uranium Stewardship.

Nuclear Energy Association

In 2014 the Organisation for Economic Co-operation and Development - Nuclear Energy Association (OECD-NEA) released its 'Managing Environmental and Health Impacts in Uranium Mining' report[14]. It emerged from the consideration that public perception issues, based on serious legacy impacts, continue to delay resource and mine development in several countries, despite the fact that uranium mining practices have evolved considerably since the mid-20th century when most legacy sites were created. The report outlines how mining has evolved to effectively manage impacts, with case studies contrasting old and new practices and outcomes. It was developed for public consultation processes, deliberately using non-technical, plain language.

FTSE4Good Uranium Mining Criteria (as an Example)

The FTSE Group (founded by the Financial Times and Stock Exchange) is now a wholly owned subsidiary of the London Stock Exchange Group and is a provider of stock market indices and associated data services. One of FTSE's global indices is the 'FTSE4Good' which is designed to

measure the performance of companies demonstrating strong Environmental, Social and Governance (ESG) practices. Note that this is one of several schemes looking at ethical investment indices, and is given here as an example only without endorsement or opposition.

Presumably because of the high profile of uranium mining amongst mining enterprises in general, FTSE4Good uses a set of uranium mining criteria to assess applicable companies as well as assessing other ESG criteria. Following an earlier 2006 edition[15], the current criteria cover fourteen areas[16]:

1. Climate Change;
2. Water Use;
3. Biodiversity;
4. Pollution & Resources;
5. Environmental Supply Chain;
6. Health and Safety (which includes the Uranium Mining criteria);
7. Labour Standards;
8. Human Rights and Community;
9. Customer Responsibility;
10. Social Supply Chain;
11. Corporate Governance;
12. Anti-Corruption;
13. Risk Management;
14. Tax Transparency.

Two examples of mining companies that are uranium producers listed in FTSE4Good are BHP Billiton (owner-operator of Olympic Dam mine in Australia) and Rio Tinto (majority owner of Rössing mine in Namibia and Ranger mine in Australia).

International Guidance (General Mining)

The international literature on the environmental and social aspects of mining in general is extensive, and a review is not attempted here. However, one overview is highlighted.

International Council on Mining and Metals

The International Council on Mining and Metals (ICMM)[17] was established in 2001 'to improve sustainable development performance in the mining and metals industry'. By the end of 2012 its members were stated to be 22 mining and metals companies and 34 national and regional mining associations. Associations involved include countries such as Argentina, Australia, Canada, Brazil, Ghana, Mexico, Peru and the USA; regions include Europe and Southern Africa; and commodity associations include aluminium, coal, copper, manganese and zinc.

The ICMM states[17] that it has five values that guide the work of the organization and members and how they interact with others:

1. Care for the safety, health and well-being of workers, contractors, host communities, and the users of the materials they produce;
2. Respect for people and the environment, ensuring that they are sensitive and responsive to the values of host societies;
3. Integrity as the basis for engagement with employees, communities, governments and others;
4. Accountability to do what they say they will do and uphold their commitments;
5. Collaboration - working with others in an open, transparent and inclusive way as they address the challenges and opportunities they jointly face.

The organisation has a number of work programs associated with these values. All members are required to implement the ICMM's Sustainable Development Framework[18], involving 10 principles for sustainable development and public reporting and independent assessment (verification of progress) in meeting those commitments. One specific document is 'Changing the Game – Communications & Sustainability in the Mining Industry'[19].

Examples of National and State Guidelines (Uranium Mining)

National guidelines and regulations regarding responsible uranium exploration and mining exist in various forms and degrees of maturity in established uranium mining countries. Examples here are from Australia, Canada and Namibia.

Australia

Australia is currently the third ranked global producer of uranium and has a history of extensive investigations and regulation of uranium mining since the 1970s. General guides have been available at a national level from government (specific to In Situ Recovery uranium mining[20]) and industry organisational levels[21], and similar guidance (for mining in general) is available from most states. Following the lifting of government restrictions general guidelines specific to uranium were issued by the Queensland[22] and Western Australian[23] state governments in anticipation of future uranium mine approval applications; in New South Wales uranium mining has been banned for some time but exploration has been allowed since 2012 under guidelines[24]. The current situation in the Northern Territory is described by Waggitt[25] and a recent industry perceptive on the situation in South Australia by Eckermann[26]. More generalized mining guidelines are available in the various Australian states, and individual guidelines are prepared for projects that require formal environmental impact assessment.

Canada

Canada is currently the second largest producer of uranium globally, and has previously held the leading position. Regulations and environmental protection measures have been well developed in recent decades. The Canadian Nuclear Safety Commission provides a standard and guidance on developing environmental protection policies, programs and procedures at uranium mines and mills (together with other nuclear facilities)[27][28][29], whilst '[e]ach province or territory is responsible for regulating and monitoring exploration activities within its jurisdiction, and for informing the public about them"[30]. A national standard for environmental monitoring programs was produced[31]. Guidelines may be set for individual projects during the proposal stage and regulations may be customized for each uranium mine or uranium mine extension, using a risk-based approach[32].

Namibia

Uranium mining has a long history in Namibia, although for many years represented only by the large Rössing open cut mine. In more recent times the industry has expanded there, and it has ranked 4 or 5 for global production in recent years. The Namibian Uranium Association (previously the Uranium Institute of Namibia), part of the local Chamber of Mines, promulgates a Standard of Good Practice for Health, Environment and Radiation Safety and Security (HERSS Standard, current version dated 2014[33]) that is to be adhered to by its members, as well as providing training courses in the field. The HERSS standards are intended to provide[34]:

1. A framework for management of health, environment, radiation safety and security in the Namibian uranium industry.
2. A reference point against which continuous quality improvement in healthcare, environmental management, radiation safety and security can take place.

The development of the HERSS Standards is promoted as an important step forward to help bring about substantial convergence between Namibian and international standards[35][36].

EXPLORATION AND FEASIBILITY

Consideration of environmental and social aspects begins at the earliest stage, when looking at where to explore or at a project to acquire. With respect to uranium, Miller[37] put it succinctly: "…one should consider the jurisdiction, stability of the government, and permitting regulations when

considering an investment in uranium exploration, mining, or signing a long term contract for the delivery of uranium", and this statement would apply no less to other commodities. State, provincial or national bans or moratoriums on the exploration and (or) the mining of uranium are known around the world; historically in Western Australia, Queensland and New South Wales in Australia, or nationally with the so-called 'three-mine policy'; in Quebec in Canada, Virginia in the United States, some provinces of Argentina (e.g. Mendoza[38]), and effectively in today's Germany. A proponent may choose to take a long-term view that circumstances will change, but such matters should be taken into account.

Social and environmental issues are important from day one of an exploration programme, even during desk-top studies. Some jurisdictions or organizations have guidelines for these aspects of (general mineral) exploration programmes (e.g. in Australia, at a state level in South Australia[39-42], Western Australia[43] and New South Wales[24]), and individual companies may have written policies or instructions to try and implement good and consistent practice.

As promising projects move from exploration to pre-feasibility and feasibility studies – in all their various names and stages – environmental studies, particularly baseline studies and the establishment of longer-term weather stations and time series data from critical environmental locations (such as, if applicable, up- and down-stream locations in a river, groundwater, atmospheric dust or radiation) should occur in parallel. Similarly, regular communication and liaison with local, potentially affected communities should commence. Environmental aspects should be considered as the evaluation of technical options for mining and processing proceeds and as preliminary mine layouts are proposed.

Examples of Social and Environmental Halts to Uranium Projects in Australia

The 'Environmental Feasibility' or 'licencibility' of a project must also be considered with geological, geotechnical, metallurgical and economic studies. Unfavourable environmental or social circumstances have changed many uranium deposits from 'otherwise economic' to 'of academic interest', or at a minimum 'on hold'. Here we put aside projects put on hold due to the so-called 'Three-Mine Policy', as influential as that was, and consider two examples from Australia, both from the Northern Territory, which whilst affected by that policy illustrate the results of an overwhelming influence of stakeholder opinion.

The Koongarra deposit was discovered in 1970; the first Environmental Impact Statement (EIS) was prepared within a few years and a mining lease subsequently granted. The second owner varied the proposal from the original one in significant ways to address environmental concerns, reportedly increasing the costs (delay costs included) by some 100%[44]. Delays continued and ownership changed; in the end the mining lease was revoked and in 2013 the area incorporated into the surrounding Kakadu National Park[45], largely at the instigation of the Traditional Owners (supported by many NGOs).

At Jabiluka, two separate Environmental Impact Statements were accepted, and a trial adit constructed, but social opposition remained[46]. Whilst the mineral lease has been retained and remains separate (albeit surrounded by) Kakadu National Park, the current owners Energy Resources of Australia (ERA, majority owned by Rio Tinto) have stated that this 'world-class deposit is under long-term care and maintenance and, in accordance with the Jabiluka Long Term Care and Maintenance Agreement, will not be developed by ERA without the approval of the Mirarr Traditional Owners'[47]. A history up until 1991 was written by the first proponent and discusses social, environmental, political and internal corporate hurdles to the deposit's development[48].

OPERATIONS AND CLOSURE

Operations

There was a time, at least anecdotally, when early 'Environmental Impact Statements' were written for the principal purpose of obtaining mine approvals and little more, becoming dust collectors on the shelves of a mine's headquarters and at some regulators and libraries, and perhaps not even available at the ensuing mine site itself. In more recent times the EIS or its equivalent – often now an Environmental and Social Impact Statement, or similar – becomes both a baseline document and leads to the first management plan for a project. These management plans, which would normally cover mining developments as well as environmental and social management plans, are and should be updated and adjusted as experience is gained and mining plans change. This has

the effect that comparisons between a predicted project, with the then-anticipated environmental and social impacts, should only be compared cautiously with actual mining achievements and actual environmental and social impacts. The story of the development of the mine and its impacts, in the light of the original baseline measurements, expected mining progression and environmental plans, and appropriate adaption and continuous improvement is as or more important than a facile comparison of, say, predicted versus actual hectares disturbed or the exact sum of royalties paid.

Mining plans that incorporate environmental plans – or environmental plans that include mining plans – are becoming the norm. These require initial approval, then periodic updating and re-approval, either after a set number of years or when significant changes to the mining plan and potential impacts are required or planned.

Considerable literature, guidance from regulators, industry associations at state (province), national and international level and publicly stated company and corporation policies are available on the subject of environmental and social responsibility in mining, and a more detailed discussion is not offered here. Virtually all mines of significant size have an environment department or similar, most often associated with health, safety and radiation protection, and often also with stakeholder and government relations. All these topics are the responsibility of senior management, both at the mine site itself and corporate headquarters. This adoption of responsibility by operational management is a positive development, and the environmental staff generally deal with monitoring and reporting and providing specialist assistance to operational departments, rather than existing outside (and possibly ignored by) the main planning and operations of a mine.

Just as with technological aspects of a mine, environmental and social aspects of a mining project should be subject to regular review and continuous improvement. Some companies offer or regulators require external audits of their environmental and safety programmes, and are subject to regulatory audits and, if required, incident investigations. Environment and safety programmes and outcomes are typically subject to a major review every few years (e.g. Beverley uranium mine[49][50], including the radiation protection arrangements[51]; Olympic Dam Project, where the Environmental Protection and Management Program (EPMP) is reported annually[e.g. 52] and typically undergoes a major revision every three years, or when a major change to operations is planned or occurs unplanned.

Closure

Many historical or ‘legacy’ sites have been known, notably in the former Soviet Union and its Eastern European associated countries, but also in the United States, Australia, Europe and elsewhere, and an extensive literature exists. From the IAEA’s perspective, “[a] key lesson learned is that a life cycle planning approach can prevent future legacies from occurring. Without this approach, potentially many millions of dollars will need to be spent on remedial actions, potentially rendering a net monetary and social loss on the mining and milling operations and certainly negatively impacting the reputation of the industry.”[1]

A modern mantra, endorsed by IAEA staff, is to plan for the end at the beginning. A section on future closure plans, albeit relatively generalised, is included in modern approval and operational documents. Often a remediation bond is required, and typically this is updated each year to reflect increased (additional areas disturbed, greater volumes of wastes to be disposed of) or decreased (areas rehabilitated, liabilities that have been dealt with) costs. The ICMM has more generalized guidance in its ”Planning for Integrated Mine Closure: Toolkit”[53].

As a project approaches the end of its life, consultation to firm up the plans, and the details in the rehabilitation plans themselves, should be expanded. Progressive rehabilitation throughout a mines’ life is recommended, both to reduce the final rehabilitation liability, but also to test and improve techniques, or solve problems of waste treatment or plant regrowth that become apparent with time compared to initial expectations.

Even relatively recent mines can have unanticipated difficulties with remediation. The example of the Nabarlek uranium mine in Australia’s Northern Territory is discussed by Paulka and Waggitt[54]. At Nabarlek production ceased in 1988 and the site remained on ‘care and maintenance’ whilst further ore was sought in the vicinity. By 1994 no viable orebody had been found and the authorities required full remediation; earthworks were completed by the end of 1995[55]. The varying attitude of stakeholders made acceptance of the rehabilitation difficult[54], and despite considerable effort and investigation[56][57], and in part because of degradation caused by a large wildfire and later a cyclone, the site has not yet been ‘signed off’[54]. Nevertheless Paulka and Waggitt conclude:

> "Important lessons have been learned from the Nabarlek story. Certainly the establishment of clear remediation objectives at the start of the project, agreement of these objectives with the stakeholders and an agreed program of review and updating would seem to be the most significant activity that might have eased some of the problems. Also today, a robust communication program to maintain contact and build trust with the stakeholders is now recognised as a 'must' for all aspects of a project but especially so in relation to remediation. It is also apparent that the need (and costs) for ongoing management and maintenance of the site can turn out to be substantial and should be assured from the start and included in all forward budget estimates relating to remediation. Finally, Nabarlek shows how remediation is optimised when tackled as a progressive activity throughout the life of a mine rather than left to the end; and certainly delays in starting work, especially after the end of production, should be avoided to optimise the chances of success.
>
> Today Nabarlek remains in the rehabilitation phase but the path towards closure is much clearer now with a stakeholder agreed and approved rehabilitation plan that includes specific and measureable closure criteria agreed for the majority of parameters."(54)

DISCUSSION AND CONCLUSION

Environmental and social aspects are key aspects of mining projects, from early exploration through feasibility, operation and closure. They are not the only aspects; without an orebody, suitable and affordable mining and processing methods, markets and financing, there can similarly be no successful mining. All feasibility, mining and indeed closure activities at a mining project require a large number of skills and specialities, which have to be balanced. Geologists, mining engineers, metallurgists, financial and senior management all need to have an appreciation of the importance of the environmental and social sides of their project, and the most effective environmental and social engagement specialists need to have an appreciation of the practical and economic aspects of those projects. Only then can a good balance be achieved, and the project given the best chance of 'triple bottom line' (social, environmental, economic) success.

The IAEA will continue to promote good practice in all stages of the uranium production cycle, but it is the industry and its regulators who must take the lead role to enable the mining (and oil and gas) industry to supply the world with its raw materials, and most of its energy, or face ongoing, justified and sometimes project-stopping opposition from the society it exists to support.

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