From: Corinne Unger
Sent: Monday, 19 August 2024 11:34 AM
To: State Development
Subject: Re: Inquiry into post-mining land use – Witness confirmation and link to witness briefing video
Attachments: Unger et al 2015.pdf; Unger 2009.pdf; Unger et al 2020.pdf

Jessie, can you please forward these two journal articles (evidence based and peer reviewed) and one Churchill Fellowship report I wrote (and is available on Churchill Trust site), to the Chair Hon Emily Suvaal, for reference if needed by the committee. I could not attach the 2 published papers in my submission due to copyright protections by journals, however I am making them available as they are relevant to beneficial and productive post-mining land use.

The 2015 paper brings together the findings of my Churchill Fellowship (attached from 2009/10 my report on abandoned mine rehab and post-mining land use) for Australia.

The 2020 paper addresses 'Transition or transformation: shifting priorities and stakeholders in Australian mined land rehabilitation and closure' mapping the evolution of mine rehab and closure in Australia. I referred to the way stakeholder expectations have evolved over time in my response to questions from Sue Higginson MLC, regarding the context for post-mining land use being important now: the 2020 paper maps this evolution more fully and provides context.

I'm happy to answer any questions, thank you

Dr Corinne Unger
PhD (Management) BScDipEd DipGeosc
Honorary Research Fellow
Business School
The University of Queensland
Brisbane QLD 4072 Australia

Resources Policy 43 (2015) 1–10

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

A jurisdictional maturity model for risk management, accountability and continual improvement of abandoned mine remediation programs

C.J. Unger [a,*], A.M. Lechner [a,b], J. Kenway [c], V. Glenn [a], A. Walton [a]

[a] Sustainable Minerals Institute, Centre for Mined Land Rehabilitation, The University of Queensland, St Lucia, Queensland 4072, Australia
[b] Centre for Environment, University of Tasmania, Private Bag 141, Hobart, Tasmania 7001, Australia
[c] Bluebird Consultants, Australia

ARTICLE INFO

Article history:
Received 27 June 2014
Received in revised form
15 October 2014
Accepted 15 October 2014
Available online 26 November 2014

Keywords:
Abandoned mines
Derelict mines
Remediation
Maturity model
Risk management
Performance evaluation

ABSTRACT

Abandoned mines can pose risks to the natural environment, humans and economies and prevent multiple or sequential uses of affected land. They range in size from individual shafts to large polluting open cut mines. Across Australia, there are over 50,000 abandoned mines on public and private land. A coordinated, effective management response is required to remediate these sites and reduce liabilities. We propose a novel maturity model for the evaluation of abandoned mine remediation programs and by applying it to Australian jurisdictions, demonstrate the potential for the model to be applied globally. The model incorporates 14 hierarchical evaluative criteria (including social, environmental and economic factors) which are each assessed against five performance indicators. These were derived from prior research and an Australian national policy for abandoned mines. We used the model to compare Australian jurisdictions to a leading practice benchmark jurisdiction, British Columbia, Canada, using web-accessible information and – in two cases – self-evaluation. The amount of publicly-available information varied widely between jurisdictions. Most Australian jurisdictions were ranked as less mature than the British Columbia program for most criteria. We then explain how the maturity model can be used to implement an existing regulatory framework specifically, the Australian Strategic Framework for Managing Abandoned Mines in the Minerals Industry, and discuss how the model can be applied to evaluate progress and prioritise improvements to abandoned mine management programs globally. A systematic approach to monitoring and evaluating abandoned mines programs is essential for improved accountability and to demonstrate change in liability over time. A systematic approach will also support shared learning and continual improvement within, and across, jurisdictions.

Introduction

Abandoned mines are alternatively termed 'derelict', 'orphan', 'former' or 'legacy' mines. These terms mean slightly different things in different jurisdictions. For example, orphan mines are those where the owner of the mine is unknown and untraceable, in contrast to abandoned mines which are "…mines where mining leases or titles no longer exist, and responsibility for rehabilitation cannot be allocated to any individual, company or organization responsible for the original mining activities" (Ministerial Council on Mineral and Petroleum Resources and Minerals Council of Australia (MCMPR/MCA), 2010). As there is no individual, company or organization responsible for managing abandoned mines, this task falls to the government and private landholders. Regardless of terminology, an attribute that all sites have in common is incomplete remediation. This can occur for a range of reasons including, but not limited to, premature cessation of operations, inadequate regulatory requirements, insufficient funds set aside for remediation, or inadequate community engagement to agree upon and meet closure expectations. While recognizing that different definitions are used for these sites, the term 'abandoned' will be used in this paper to represent all forms of mining legacies which by default have become the responsibility of governments and the community.

Abandoned mines (AMs) have accumulated in many countries globally over decades or centuries. Most originated in times when mining environmental standards and community expectations were much lower than at present. In Australia responsibility for abandoned mines can be unclear, however with a few exceptions in the Northern Territory (Department of Mines and Energy, Northern Territory (DME NT), 2013; Fawcett, 2012; Waggitt and Fawcett, 2008) state and territory governments have become responsible for abandoned mines on government owned land. Despite current freehold landholders not having mineral rights or

* Corresponding author. Tel.: +61 417550021.
E-mail addresses: c.unger1@uq.edu.au (C.J. Unger), Alex.Lechner@utas.edu.au (A.M. Lechner), jessica.kenway@gmail.com (J. Kenway), v.glenn@uq.edu.au (V. Glenn), coolbluekoala@hotmail.com (A. Walton).

http://dx.doi.org/10.1016/j.resourpol.2014.10.008
0301-4207/

Table 1
Risks and opportunities commonly associated with abandoned mines (adapted from Eden Project Post-Mining Alliance, 2008; Unger et al., 2012).

Key risk or opportunity	Common examples
Human health/Safety risk	Exposure of local communities to contaminants
	Open pits and shafts
	Failure of tailings containment facility or other impoundments
Environmental risk	Contaminated land and water
	Biodiversity loss
Socio-economic risk	Communities left without livelihoods
Economic risk	Liabilities to state and landholders
	Litigation risk to the State
	Rehabilitation cost
Reputational risk	Loss of mining company social license to operate
	Loss of confidence in governments' ability to regulate mining
Beneficial opportunities	Domestic waste disposal in voids
	Mining heritage and geo-tourism
	Secondary mining opportunities
	Alternative land uses

the ability to prevent access to those minerals by third parties approved by the State government, it was the opinion of departmental staff that freehold landholders are deemed responsible for abandoned mines on freehold land in Queensland (Queensland Flood Commission of Inquiry, 2012).

Abandoned mines pose a challenge to governments and societies striving towards the sustainable development concept of inter-generational equity. There is global recognition that "some impacts [from abandoned mine sites] can be long-term and that society is still paying the price for natural capital stocks that have been drawn down by past generations" according to the report by the International Institute for Environment and Development and World Business Council for Sustainable Development (IIED/WBCSD, 2002).

The scale of the issue is significant, both in terms of the number of sites and estimated remediation costs, and compounded by the complexity and potential range of impacts (Table 1). A recent report found over 161,000 abandoned hard rock mine sites in the US (Government Accountability Office (GAO), 2011). The United States Environmental Protection Agency Office of Inspector General determined that cleanup of 63 hardrock mining sites on the National Priorities List would cost up to $7.8 billion (Lovingood et al., 2004). In Canada, a major review of contaminated lands, including abandoned mines, estimated liabilities for abandoned mine sites at over C$555 million for sites under federal jurisdiction alone (Office of the Auditor General of Canada, 2002). Even in Australia with its shorter mining history, it is estimated that there are in excess of 50,000 abandoned mines ranging in size from individual shafts to large polluting mines (Unger et al., 2012). However, abandoned mines may also leave positive values such as voids suitable for domestic waste disposal, heritage features for tourism and secondary mining opportunities as well as new, alternative land uses (Eden Project Post-Mining Alliance, 2008; Unger et al., 2012) (Table 1).

Recent rapid growth in the resources sector globally, and particularly in countries such as Mongolia and Australia (Lechner et al., 2014; Petkova et al., 2009), has placed significant demands on regulatory personnel responsible for the approval of new mines and upstream petroleum industries, resulting in far less attention being applied to environmental management of abandoned mines. Factors contributing to this include competing priorities for human resources and funding within government and industry, the costs of managing legacy issues associated with abandoned mines, jurisdictional ambiguity over responsibilities and an absence of legislation to set the standard for their management (Queensland Flood Commission of Inquiry, 2012). Abandoned mine remediation planning at a jurisdiction level is challenging because it requires a thorough understanding of abandoned mine causes, impacts and legal contexts to develop policies. Multidisciplinary teams are then required to formulate technical solutions embedded in a sound framework for prioritization.

The aim of this paper is to propose a model of leading practice abandoned mine management that is integrated into an existing regulatory process. The model draws upon leading practices globally to aid in the implementation and improvement of abandoned mine programs. This model is based on a graded maturity model, whereby performance is assessed for a range of evaluative criteria such as the quality of an abandoned mine inventory and risk assessment tools. This method is consistent with the trend in many other sectors, which use scales or rubrics for evaluation purposes (Davidson, 2005). We then apply the maturity model to Australian jurisdictions, as a case study, assessing the progress of abandoned in management for seven states and territories. This assessment is based on a web search, using publicly available information and self-assessments conducted by two of the jurisdictions. We compare these results to the contaminated sites program in British Columbia, Canada (BCCCSP, 2012), which is considered a benchmark for leading practice globally (Unger, 2009). Using this case study, we demonstrate how a maturity model can assist jurisdictions by indicating how advanced their programs are along the maturity path. This information can allow jurisdictions to identify where they are positioned now and where they want to be in the future. Finally, we show how the maturity model could also be used as a basis for supporting existing regulatory processes through the development of an implementation plan for Australian jurisdictions and industry.

Method

Background to the maturity model

Monitoring is the regular collection and analysis of information to provide an indication of progress towards a desired end-point or objective. Evaluation is a process that seeks to determine the merit or worth of an object, program or policy as systematically and objectively as possible (Owen, 2006). Monitoring and evaluation are used within government and the private sector to: ensure accountability for resource expenditure; inform strategic decisions; and to improve future performance through learning from past experiences (e.g. Department of Agriculture, 2009, Caring for our Country, 2014). Monitoring is also a vital component of risk management to ensure early detection of problems and to guide preventative actions (Kusek and Rist, 2004).

In this paper, we propose a systematic approach for monitoring and evaluating government abandoned mine programs based on the concept of a maturity model. Maturity models, or graded rubric scales are used in a number of other sectors (e.g.: safety prioritization (NSW government, 2011; Westrum, 1993); organizational development (Esteves et al., 2010); and student assessment (Davidson, 2005). This is the first time this approach has been proposed for the evaluation of abandoned mine rehabilitation programs.

A maturity model maps a program's 'journey' from poorly structured toward an integrated, systems-based approach to management. Westrum's (1993) maturity model identified three types of culture: Pathological, Bureaucratic and Generative. Adaptations of this model commonly include additional performance categories. For example, Hudson and van der Graaf (2002) adapted Westrum's (1993) maturity model for safety culture by replacing the 'Bureaucratic' category with Reactive, Calculative and Proactive.

The maturity model approach highlights that effective risk management systems involve several step changes and include two broad elements common to evaluation rubrics (Davidson, 2005): i) evaluative criteria and ii) merit determination. Evaluative criteria describe the aspects of performance that are the focus of evaluation. Merit determination reflect categories used to asses performance for each of the evaluative criteria.

Evaluative criteria and performance assessment

We identified 14 evaluative criteria to define the maturity of jurisdictional abandoned mine programs from leading practice programs internationally (Unger, 2009), the five chapters of the Australian Strategic Framework for Managing Abandoned Mines in the Minerals Industry (hereafter, the "Strategic Framework"; MCMPR/MCA, 2010) and previous research on maturity models for abandoned mines (Unger et al., 2014). The Strategic Framework formed the basis of the evaluative criteria as it was developed by the Abandoned Mines Working Group comprising abandoned mine managers from within most state governments (not all jurisdictions have formal abandoned mine programs) and representation from the Minerals Council of Australia (MCA). The Strategic Framework describes five components (presented as separate chapters) required for successful management of an abandoned mine program with the aim to encourage convergence of state and territory jurisdictions on the following aspects: i) site inventories and data management; ii) improved understanding of liability and risk relating to abandoned mines; iii) improved performance reporting; iv) standardization of processes and methodologies; and v) knowledge and skill sharing across jurisdictions. The order of our evaluative criteria based on the Strategic Framework is in line with the maturity approach where the earlier criteria describe foundational elements for new abandoned mine programs (Fig. 1).

Our maturity model consists of five categories of performance assessment for each of the 14 evaluative criteria identified in the previous step. These categories are an adaptation of an approach used in the mining context by Anglo American and Joy in 2007 (in Foster and Hoult, 2013). The categories used in our maturity model are: vulnerable, reactive, compliant, proactive, and resilient. Indicators are balanced around the central maturity indicator 'compliant' which means there are systems in place (Hudson, 2001 in Commonwealth of Australia, 2008), but the organization may not yet be focussed on continual improvement or anticipating problems before they arise. Vulnerable and reactive programs lack the information needed to make good decisions and prioritise abandoned mine sites. They also lack systematic methods for addressing abandoned mines. 'Resilient' is the highest stage of program maturity and goes beyond proactive, indicating that information is shared across jurisdictional boundaries and global leading practices solutions/method are sought out to improve on local benchmarks. For the purpose of this review we used simplified indicators to aide clarity (Table 2). Thus, in our maturity model both evaluative criteria and performance assessment can be used as indicators of a well-developed and mature abandoned mines program.

Reviewing and ranking jurisdictions: maturity model trial application in Australia and international best practice representation

We reviewed all states and mainland territories of Australia excluding the Australian Capital Territory (which comprises a

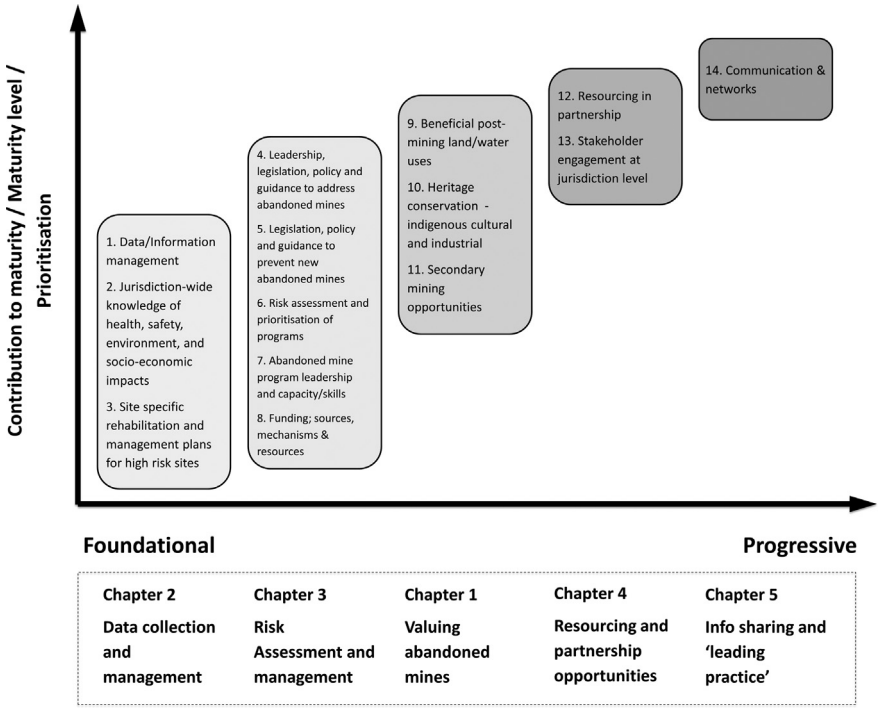

Fig. 1. Evaluative criteria of a mature abandoned mine program and relationship with Strategic Framework.

Table 2
Jurisdictional maturity model for abandoned mine management (Adaptation of Unger et al. 2014).

	Performance indicators	Vulnerable (1)	Reactive (2)	Compliant (3)	Proactive (4)	Resilient (5)	Strategic framework chapter*
	Evaluative criteria				in addition to complaint…	in addition to proactive…	
1	**Data/information management**	No data and no inventory evident;	Some data on some sites, outdated inventory insufficient to make decisions on which sites require management;	An inventory exists of jurisdiction-wide abandoned mines with sufficient information to prioritise sites;	Actively addressing data and information gaps; Regular improvements to integrate data management system;	Inventory data can be compared across jurisdictions; Clear evidence of collaboration;	**Chapter 2: Data collection and management**
2	**Jurisdiction-wide knowledge base of impacts and opportunities (health safety, environmental and socio-economic)**	No details available on safety, health or environment or socio-economic impacts;	Some knowledge has been gathered for some sites, but not whole jurisdiction;	Knowledge base exists for whole jurisdiction, gaps exist but a program is in place to address gaps	Most of the key knowledge gaps have been addressed with high quality documentation; National high risk sites and priorities have been identified;	Knowledge shared widely via detailed plans, published papers, peer reviewed reports;	
3	**Site specific data for high risk /priority sites**	No site specific data for individual sites;	Site specific data for 1 to 2 sites but little if any review or interpretation;	Priority sites have data collection programs with evidence of third party review/ interpretation	Interpreted reports on priority sites available; Evidence that new knowledge informs planning;	Sharing of information within government and across jurisdictions; Actively engaging stakeholders in knowledge gathering and management;	
4	**Leadership, legislation, policy and guidance to address AMs**	No policy or legislation to address abandoned mines; Responsibility unclear;	Legislation and policy for a few sites but not the whole jurisdiction; Responsibility involves multiple agencies;	Policy and legislation addressing AMs exist, one agency leads coordination of program; Regular performance reporting; Engagement with, and support from, key stakeholders;	Policy and legislation implementation supported by toolkits, training and case studies which encourage innovation; External technical expertise engaged on discipline-specific review and prioritization; Collaboration with other jurisdictions where impacts go beyond borders;	Wide stakeholder engagement ensures active involvement in AM management/remediation and/or post-mining land use; Evidence of beneficial post-mining land use; Peer reviewed published articles on AM program, its elements and case studies highlighting progress;	**Chapter 3: Risk Assessment and management**
5	**Leadership, legislation, policy and guidance to prevent new AMs**	Existing regulation of mines is weak or absent on rehab and closure;	Some regulations exist to prevent future abandoned mines, with little or no enforcement;	Range of legislative mechanisms applied to prevent AMs, such as incentives, bonds, rehabilitation/closure planning guidance and review processes;	Team of regulatory rehabilitation/ closure experts systematically auditing, and taking action at, high risk sites;	Continual improvement has eliminated future legacies defaulting to the state/ tax payers/community;	
6	**Risk assessment and prioritization of programs**	No evidence of a state/NT-wide risk assessment process;	Ad hoc risk assessment for some sites undertaken but not applied across whole jurisdiction to identify high risk features and sites;	Jurisdiction-wide risk assessment applied (features and whole mine risks able to be quantified), Control measures for significant risks included in implementation plan(s); Internal reporting on program;	Evidence that significant site/feature implementation plan is successfully being deployed; Performance evaluation methods defined; Public performance report on expenditure and risk/liability reduction;	Risks well understood and prevented, routinely the 'way we do business'; Little or no chance of unpredicted significant risks;	
7	**Abandoned mine program leadership and capacity**	No permanent personnel working on AMs;	Some permanent personnel and/or temporary personnel working on AMs, but role (s) shared with regulatory or other functions;	AM team 100% focussed on abandoned mine management, leading the program strategic planning and implementation; Skills and expertise aligned with roles;	Training program, succession plan and mentoring sustains AM team;	Other jurisdictions seek advice from this team because of the caliber of leadership;	
8	**Funding – sources, mechanisms and resources**	No funding for an AM program;	Base funding focused on specific sites over short time frames (up to 3 years);	Base funding and project funding for jurisdiction-wide program, able to plan ahead 3 to 10 years ahead;	Systematically reducing liability and reporting on performance; Regular reviewing of additional/ alternative funding mechanisms	Multiple funding sources, significantly reduced liability for state/community;	

				through effective stakeholder engagement;			
9	**Beneficial post-mining land use**	No evidence of successfully managed or closed AM with beneficial post-mining land use;	Evidence of shaft capping programs which have successfully facilitated access to land by making safe;	Evidence of beneficial post-mining land use on 1 to 3 sites following implementation of remediation/closure plans, evidence of stakeholder acceptance;	Evidence of multiple AMs (>3) which have been remediated /closed and have enabled beneficial land uses, Innovation evident through active research program;	Leading practice AM management; Most closed sites returned to productive/beneficial land uses; Sharing of knowledge with related sectors (quarrying, waste management, etc);	**Chapter 1: Valuing abandoned mines**
10	**Heritage conservation – indigenous and industrial**	No evidence of heritage conservation integrated with AM program; Heritage values harmed during shaft capping earthworks;	Indigenous and industrial heritage surveys and planning studies carried out on a few sites;	Heritage conservation management plans being implemented on all heritage listed sites; Evidence of indigenous engagement in closure planning;	Conservation/indigenous engagement integrated with rehabilitation, with specialists guiding works and training in-house personnel, research published;	Iconic heritage sites listed on national heritage register; Tourism entity functioning with multiple collaborators and funding streams; Restoration of cultural heritage (indigenous) landscape features;	
11	**Secondary or complementary mining opportunities (industrial ecology)**	No evidence of secondary mining projects at an AM in the jurisdiction;	1 to 2 examples of potential secondary mining or other activities which reduce liabilities at an AM (exploration and/or mining tenure);	Several (>2) examples of secondary mining or other management arrangements which devolve site responsibility to a third party and reduce liabilities to the state by use of robust agreements; Secondary mining plans based on accepted standards;	Innovative projects reduce waste volumes at AMs via alternative uses of materials and improved re-processing techniques derived through research; Greatly reduced liabilities for the state;	Significant proportion of AM's have third party managers/users of site wastes/water with little or no ongoing responsibility or liability for the state;	
12	**Resourcing in partnership**	No evidence of partnering with other organizations on AM management;	Evidence of partnering on <2 projects on site specific activities;	Partnering on AM program at jurisdictional level, e.g. with another government department, industry, research organization or non- government organization such as heritage/historical, tourist entity;	Clear measures of success of the partnership with communication; Review by independent parties; Collaborative publication of program /case study updates;	Partnerships constitute a global leading practice example and other nation-delegations visit to learn from it;	**Chapter 4: Resourcing and partnership opportunities**
13	**Stakeholder engagement**	No evidence of jurisdiction-wide stakeholder engagement;	Stakeholder engagement occurs on a few sites of concern/interest;	Stakeholder engagement occurs through a regular cross-functional advisory group within government; Site specific stakeholder groups including industry professionals to inform planning and implementation;	Stakeholder advisory group including regional catchment bodies, provide input to AM program providing guidance on environmental values and priorities; External technical expertise engaged to review priorities;	Stakeholders involved at all stages, including review of performance and input to public performance reporting; Participatory monitoring methods employed widely;	
14	**Communication and networks**	No evidence of networks or communications across departments;	Web-page exists, provides overview of abandoned mine works, little evidence of networking	Cross-departmental communication and networks with other organizations; Cross-jurisdictional communication on challenges in common; Regularly updated webpage(s).	Regular newsletters and public communication on AM challenges and solutions engage stakeholder groups more widely with collaboration making efficient use of limited resources;	Communications linked to global networks with information sharing between jurisdictions and nations (developed and developing) via a range of mechanisms;	**Chapter 5: Info sharing and 'leading practice'**

AMs – abandoned mines.

relatively small land area) and compared their abandoned mine management framework and practice to British Columbia, Canada. Australia was chosen as a case study to evaluate our model because like many developed and developing nations, it has experienced recent growth in its mining and petroleum extraction sector yet does not have a national authority for managing abandoned mines. Furthermore, it is relatively straightforward to collect web-based information. The jurisdictional rankings were derived only from a range of web information sources as a way of evaluating the abandoned mine program information that is accessible to the general public.

The British Columbia Crown Contaminated Sites Program (BCCCSP) was also assessed in our analysis as previous research has identified it as a benchmark for leading practice globally (Unger, 2009; Unger et al., 2012). This program has addressed the recommendations of various reviews including an audit by the Auditor-General (Office of the Auditor General of British Columbia, 2003). The BCCCSP has evolved to a sophisticated program addressing a range of regulatory, personnel, information management, accountability and transparency challenges (Unger, 2009; BCCCSP, 2012; 2014).

This web-based review was undertaken by a researcher with very little experience in abandoned mines to ensure that the rankings were not biased by inside knowledge of the industry. The scores for each jurisdiction and British Columbia were then plotted in a spider chart to provide a graphical representation of this multivariate data in two dimensions.

In addition to our independent evaluation, we requested self-evaluations from each jurisdiction. Only two self-evaluations were obtained in response to our request (South Australia and Tasmania). The self-evaluations provide a subjective method for evaluating the accuracy of the web-based review method.

Finally, a hierarchical cluster analysis was performed to provide an exploratory assessment of which jurisdiction had similar patterns in evaluative criteria and performance indicator scores. It provided a single descriptive method for summarising the rankings of 8 jurisdictions, 15 evaluative criteria and 5 performance indicator scores. The cluster analysis was conducted in R using the pvclust package version 1.2-2 (Suzuki, 2013).

Results

Information sources

The web-based information sources used in our review varied from dedicated web sites for jurisdiction-wide abandoned mine programs to information on abandoned mines specific to just one or two sites (Table 3). As the term ‘abandoned mines’ was not used by every jurisdiction, searches under other associated terms were needed to locate relevant programs or site information (Table 3). This was the case for Victoria, for example, which yielded no information using ‘abandoned mine’, however the search term, ‘contaminated sites’, proved more effective revealing a reference to an audit by the Victorian Auditor Generals Office (VAGO, 2011) with recommendations for two government departments as well as councils who are ‘not effectively managing contaminated sites…’. Similarly, in British Columbia, the term ‘contaminated sites’ provided jurisdiction-wide information via the Crown Contaminated Site Program web site and associated biennial performance reports (BCCCSP, 2012; 2014).

Ranking

Our web-analysis found large variability in the maturity of abandoned mine programs for a range of evaluative criteria across Australia. Western Australia ranked highest (proactive – four) for criterion one (data and information management), due to their comprehensive WABMINES database (Strickland and Forbes; 2004), while having a score of zero for two other criteria (Fig. 2). A score of three was achieved by the Northern Territory for criterion five (Legislation, policy and guidance to prevent new AMs) due to the evidence of methods for prevention of mining legacies and detailed data on two particular sites, Mt Todd and Rum Jungle (DME NT, 2013). New South Wales and Tasmania had the highest average score of 1.7, however, this was not much higher than the overall average for jurisdictions in Australia at 1.5 and is thus well within the bounds of uncertainty associated with the web search method.

On average, Australian jurisdictions ranked lower than British Columbia for most categories with an average score of 1.5 versus 3.1, respectively. Our cluster analysis, which identified similarity in rankings for evaluative criteria, also showed that British Columbia is very distinct in comparison to Australian jurisdictions (Fig. 3). The clustering reflects not only the scores for the performance indicators but also the evaluative criteria in which each jurisdiction shows maturity. For example, the Northern Territory and Victoria are clustered as they had the lowest average scores of 1.1 and low values in similar criteria, while Queensland and Western Australia were also clustered as they both score highly in the foundational evaluative criteria.

All programs rated very low for criteria 10 (Heritage conservation – indigenous, cultural and industrial) and 11 (Secondary mining opportunities), including British Columbia, Canada. This does not mean these values were not being addressed at any sites. Rather – as with each of these scores – these results reflect the web-accessible information based on what a member of the public could find if they were searching for this information. The unexpectedly low score (3) for British Columbia's beneficial use of post-mining landscapes (criterion 9) in the context of the British Columbia Brownfield Renewal program (British Columbia Brownfield Renewal, 2014) is

Table 3
Summary of web-based information sources.

Jurisdiction	Website information scale	Key search term	Summary of available information
Australia			
New South Wales	Jurisdiction-wide	Derelict mines	Program website; Current program of works
Northern Territory	Site-specific	Legacy sites	Site-specific programs (Mt Todd, Rum Jungle); Mine levy for AM management
Queensland	Jurisdiction-wide	Abandoned mines	Program website; Five site-specific programs; Two shaft-capping programs
South Australia	Site-specific	Abandoned mines	Program identified; Site-specific program (Brukunga)
Tasmania	Jurisdiction-wide	Abandoned mines	Program website; Policy, criteria for site prioritization, cross-functional engagement – trust fund committee.
Victoria	Site-specific	Contaminated sites	List of priority sites includes four former mines; no site-specific remediation details, jurisdictional audit reports
Western Australia	Jurisdiction-wide	Abandoned mines	Jurisdiction-wide inventory, mine rehabilitation fund
Canada			
British Columbia	Jurisdiction-wide	Contaminated sites	Program website; Performance reports

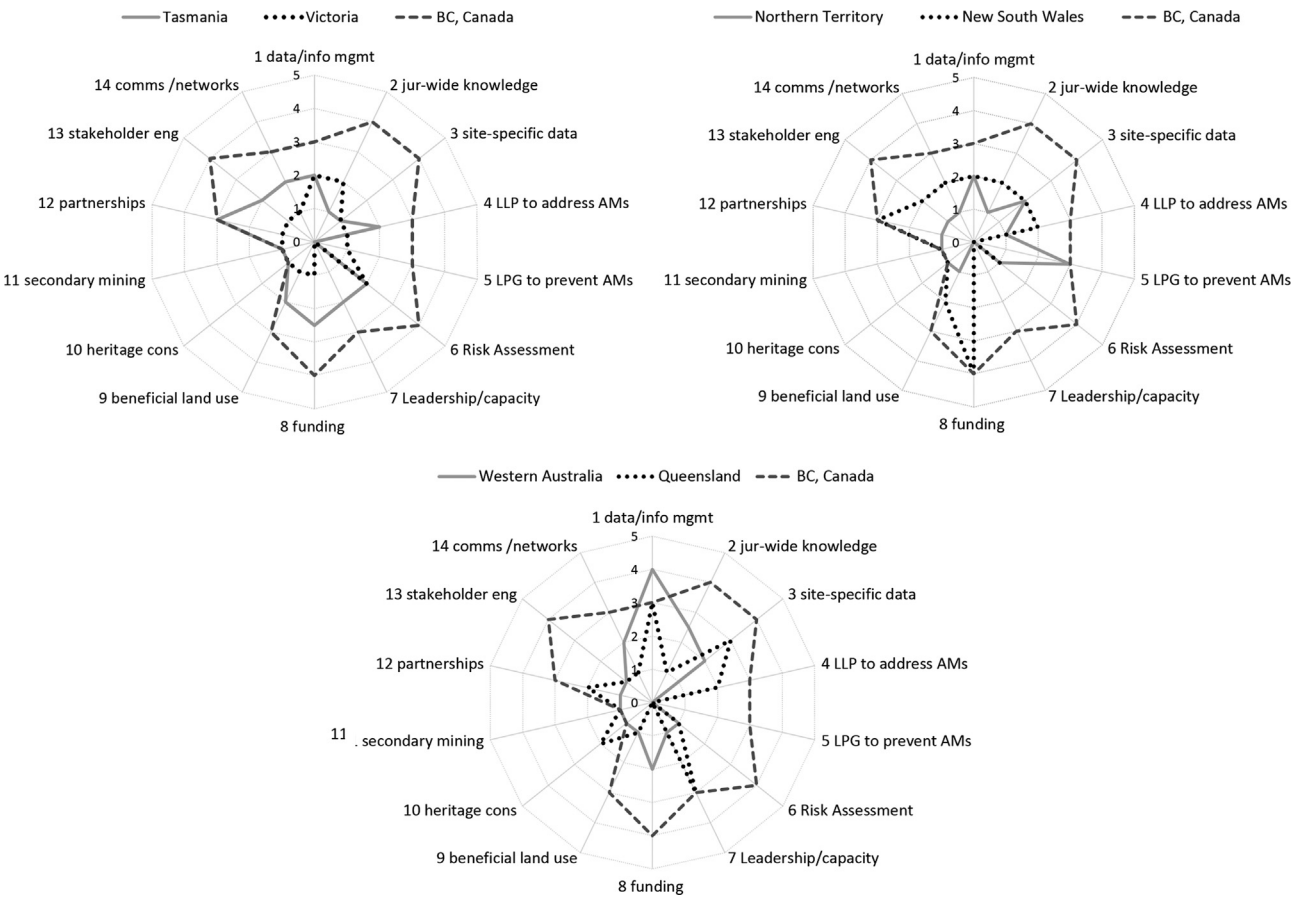

Fig. 2. Spider diagrams of jurisdictional maturity for abandoned mines for Australian jurisdictions and British Columbia (BC), Canada.

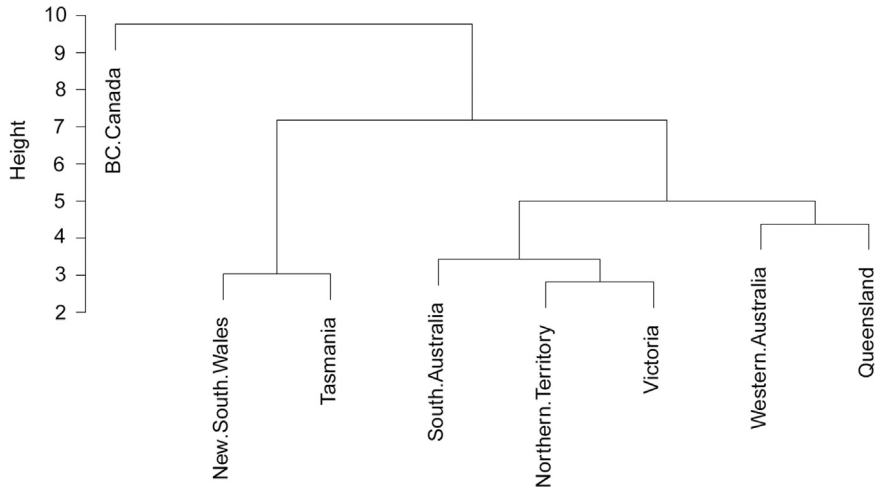

Fig. 3. Hierarchical cluster analysis of jurisdictional maturity for abandoned mines for Australian jurisdictions and British Columbia, Canada. Height indicates the degree of similarity between jurisdictions.

because this program was not found during the web-analysis, nor its connection to the Crown Contaminated Sites Program recognized. While some abandoned mines are included in the Brownfield Renewal program, many sites are other types of industrial sites located in urban areas where land values are higher than remote BC.

Self-ranking

While the web-analysis reflected information available to a member of the public, the self-assessments conducted by Tasmania and South Australia showed that the independent assessment was only accurate for some of the evaluative criteria (Fig. 4). Both self-assessments resulted in higher overall scores as would be expected given that less information is available publicly. The difference between the self-evaluation and the web-based average scores was 1.1 and 0.6 for Tasmania and South Australia respectively. However, the difference between five out of the 14 evaluative criteria and seven out of the 14 criteria were less than 0.5 for Tasmania and South Australia respectively, demonstrating that many of the criteria were assessed reasonably with the web-based approach.

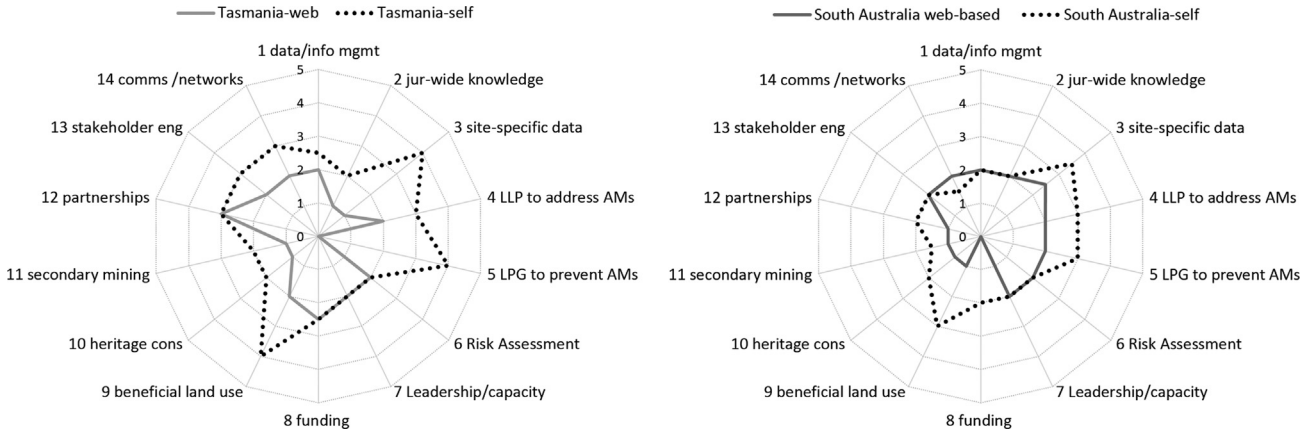

Fig. 4. Spider diagrams of jurisdictional maturity for Tasmania and South Australia comparing independent web-based assessment with self-assessment.

Discussion

The abandoned mine maturity model presented in this research illustrates a novel application of the maturity model concept. It allows for the strengths and weaknesses to be identified in current approaches to abandoned mine management taken by each jurisdiction against current international practice. It also allows for performance evaluation of abandoned mine programs against the maturity pathway.

Outcomes for Australian jurisdictions

The independent review based on web-accessible information made apparent that some Australian jurisdictions were more mature in some criteria than in others. In most cases, the British Columbia Crown Contaminated Sites Program was more mature than abandoned mine management under Australian jurisdictions. The variability in abandoned mine maturity over the range of evaluation criteria highlights that cross-jurisdictional dialog is likely to be beneficial. For example, the Western Australia abandoned mine mapping program resulted in a high score for criterion 1 (data and information management) and other jurisdictions are likely to benefit from their experience. While the average of all scores for Australian jurisdictions was 1.5, the average of the maximum scores for each evaluation criterion across all Australian jurisdictions was 3.2. This value is similar to the result for our leading practice benchmark of British Columbia, Canada (with an average score of 3.1). Therefore, sharing knowledge within Australia and linking jurisdictions to leading practices overseas would assist abandoned mine managers to continually improve towards leading practice.

For the criteria against which jurisdictions appeared weaker, the maturity model provides an indication of step-wise improvements that could be taken on the path to maturity. Furthermore, the evaluative criteria are ordered in a manner logically consistent with leading practice internationally and thus, effort should be prioritized towards strengthening program performance in the foundational evaluative criteria (i.e., starting with data/information management and establishing a jurisdiction-wide knowledge base). Deviations from this, indicated by high scores in upper-level criteria, may serve as a warning that the necessary preliminary information or program development has not been undertaken.

A key piece of information missing from most websites was the total liability from abandoned mines and methods of prioritization and risk assessment. It was not clear whether this liability was known or if the information was not released publicly. Where abandoned mine programs existed in Australia, the program expenditure *per annum* was also missing from their websites. As a result, researchers and the public cannot easily assess how much of the total abandoned mine liability is being addressed each year and the scale of the problem. This is in contrast to some of the US and Canadian programs that have publicly available estimates (e.g. BCCCSP, 2012; Lovingood et al., 2004; Office of the Auditor General of Canada, 2002;). Risk and prioritization information commonly utilize estimates of site liability – together with environmental, safety and health risk data – to identify which mines to apply investigative focus. Investigations then identify the risk consequences and probability so that high risks are identified and given priority for remediation action. Site liabilities can then be estimated. The lack of liability reporting in Australia could represent the fact that investigations and risk rankings have not been undertaken. The absence of accurate estimates of abandoned mine liabilities indicates a significant shortcoming in abandoned mine management in Australia when compared with Canada.

While care was taken to review all publicly available web-based information, it is likely that this review underestimated maturity across jurisdictions and those jurisdictions that have emphasized transparency would have received higher scores. For the two cases in which jurisdictions self-evaluated, their evaluation scores were much higher. The web-based evaluation of South Australia appeared to more closely resemble the self-evaluation than Tasmania. Perhaps this was due to their advanced planning and investment for one site in particular, Brukunga, in South Australia which has involved remediation planning over many years, concurrent with water treatment (Department of Manufacturing, Innovation, Trade, Resources and Energy, 2013). In Tasmania, where Mineral Resources Tasmania are the lead agency for rehabilitation of abandoned mine lands, there appears to be greater jurisdictional planning with a cross-functional Trust Fund Committee to provide advice to the Minister on allocation of funds to abandoned mine remediation.

The web-based review makes assumptions based on the information provided on web sites. Wherever quantitative data was not available, subjectivity could have been a factor in the ranking. For example, during the ranking process, it was apparent that the researcher needed to know all of the possible terminology for abandoned mines in order to find relevant information. The search phrase ‘abandoned mines’ was not used by all jurisdictions, with jurisdictions using terms such as contaminated sites, legacy sites and derelict mines (Table 3). In some cases, there was no online inventory for abandoned mine sites. For example, few, if any, Northern Territory legacy sites were truly abandoned as they were often incorporated into mining tenure for current projects. Under the operator's Mine Management Plan and associated rehabilitation bond, the company would not become responsible for the pre-existing site liability until they undertook new mining

activities in former mining areas. However, this is not easy to determine from a web search. Thus, those programs that have a unified and dedicated program are likely to have higher rankings. Furthermore, the management of abandoned mines is constantly evolving and our trial of the maturity model represents the state of abandoned mine management in Australia as of July 2013 when the review was completed. Some jurisdictions have since made significant changes that may raise their scores against the evaluative criteria such as Western Australia (Western Australia Department of Mines and Petroleum, 2014) and Northern Territory (Clayton Utz, 2013; Woollard, 2014).

Maturity model for monitoring and evaluation

Through further testing and refinement, and with input from jurisdictional abandoned mine managers, the maturity model could be applied to jurisdictions globally to address gaps or weaknesses in policies, legislation and programs. Maturity models have successfully been applied in other areas globally. For example, maturity models have been applied to safety in the mining and other industries (Commonwealth of Australia, 2008; Hancock, 2010; Hudson and van der Graaf, 2002; Westrum, 1993). Hancock (2010) applied the maturity model to risk management of communicable diseases in the Papua New Guinean mining industry to provide a path for development. He stated that, "the maturity model can be used to heighten awareness of the strengths and weaknesses of an organization, to prioritise effort in organizational improvement activities and to provide a vision of mature application of the risk management process and the journey by which maturity may be attained". Hancock's applications of the model are similar to those outlined by MacGillivray et al. (2006 and 2007) which include use of the model: i) by the organization as a self-assessment tool; ii) by management and technical staff as a reference model; and iii) to evaluate contractors or partners.

The maturity model is just one of many monitoring and evaluation tools that may be applied to abandoned mines. An evaluation of the range of circumstances that have led to the occurrence of abandoned mines can provide useful context and knowledge to help inform current mining practices, regulation and policy to reduce the likelihood of them developing in the future. The monitoring and evaluation literature advocates that quantitative approaches be applied to program evaluation. Future research based on the principles of Utilization Focused Evaluation (Patton, 2008; 2013) could be used to further refine this maturity model. This approach focuses on the principle that an evaluation is most useful when assessed by its intended users and thus, jurisdictions should adapt our maturity model to their specific requirements.

Integrating the maturity model with existing frameworks

The maturity model could form the basis for achieving implementation of existing regulatory frameworks or policies that have been developed by jurisdictions at any level globally. Strategic-level documents lack the level of detail required for implementation and jurisdictions – particularly, but not exclusively, those in developing nations – may lack suitably qualified personnel to translate policy into workable plans with clear task prioritization. The maturity model presented here provides a hierarchical, step-wise guide to developing a robust abandoned mine management program. The model could also support the development of appropriate tools to assist knowledge sharing and progression of abandoned mine programs along the path to maturity based on the well-established monitoring and evaluation principles referred to earlier.

This paper demonstrates in the Australian context how a strategic framework could be developed into a maturity model through adapting the chapters of the strategic framework and leading global leading practice into evaluative criteria. An implementation plan for the Strategic Framework is the next step in addressing abandoned mines in Australia and would provide minimum jurisdictional expectations to encourage convergence across jurisdiction boundaries and give rise to a consistent national approach, as has occurred for the National Mine Safety Framework (MCMPR, 2009). Targets would need to be set and performance measures agreed. It is anticipated that this maturity model could provide a foundation for this plan by enabling jurisdictions to map a path toward the leading practice programs. Gaps in knowledge, policy and legislation can then be systematically addressed for holistic programs to persist over time, including across changes of government. Inter-generational equity demands long-term persistence in abandoned mine programs.

Conclusions

In this paper, we presented a novel application of the maturity model to jurisdictions managing abandoned mines to highlight the benefits of understanding key elements against which management inputs are required. Appropriate monitoring and evaluation tools, such as the maturity model, are needed to assess performance, while also supporting learning between jurisdictions that have responsibility for abandoned mines. This approach can improve efficiency and progress toward adoption of leading practices via information sharing. Applying our model to assess the performance of Australian abandoned mine plans and programs showed that Australian jurisdictions appeared to be at the foundational steps in addressing abandoned mines issues.

The complexities of abandoned mines and their potential for long-term impacts require that robust management programs be developed. Any jurisdictional abandoned mine program can potentially fail if a systematic approach is not taken to assessing outcomes in an objective and quantitative manner. These programs are also vulnerable to political involvement in decision making, particularly when economies contract. Robust programs that are strongly evidence-based ensure that the key risks and liabilities are identified, quantified and become the focus of remediation. National leadership to achieve a connection to global leading practices can bring innovative solutions to address impacts and harness the opportunities from those values that some abandoned mines have, such as industrial heritage values. Innovation in methods and collaboration can provide beneficial post-mining opportunities and sustainable local economies.

Acknowledgments

The authors would like to acknowledge the support of colleagues, David Mulligan, Mansour Edraki and Ros Howse, during this research. We would also like to acknowledge the Centre for Mined Land Rehabilitation, The University of Queensland, for supporting this research.

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THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by Corinne Unger

2009 Churchill Fellow

The James Love Churchill Fellowship to study leading practice abandoned mine rehabilitation and post-mining land use projects in Austria, Germany, England and Canada.

I understand that the Churchill Trust may publish this Report, either in hard copy or on the internet or both, and consent to such publication.

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Signed ……. Dated 28 November 2009

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[1] Case studies from IBA-SEE conference presentations

1 INTRODUCTION

I have been involved in land rehabilitation for about 25 years. Initially I was employed as a Soil Conservationist with the NSW government, then in the mining industry in the Northern Territory (NT) for ten years, where I specialized in mine rehabilitation and coordination of research at a uranium mine. This work extended to other mines in Australia when that company formed a consulting group. After moving to Rockhampton, I developed an abandoned mine rehabilitation project team within the Queensland Government. We then developed a rehabilitation plan for Mount Morgan Abandoned Mine. In the last five years as an environmental consultant, I have managed projects, provided training and given advice on mine environmental research and rehabilitation planning across a range of projects and environments.

Abandoned mines pose unique and often complex challenges because rehabilitation has either been inadequate or absent, leaving negative impacts such as;

- safety hazards for humans and other animals;
- environmental impacts;
- neglected mining heritage and other assets; and
- depressed communities.

Abandoned mines have no company managing those impacts after extraction of the mineral resource and governments either accept, or inherit by default, these liabilities. 'Derelict', 'orphaned' and 'legacy' are also terms used by different government jurisdictions to describe abandoned mines.

A range of factors can lead to the existence of an abandoned mine. A significant factor is the absence of regulatory controls when mining was undertaken and a lack of, or insufficient, financial assurance, set aside for rehabilitation which modern mining regulation requires. Lower community expectations were reflected in historically 'weaker' regulation of mining. Economic factors are also important as they determine the value of mining commodities and shape the 'boom and bust' cycles. Downturns in the economy, or within one sector, can lead to operations going into liquidation. Each abandoned mine has its own history. However, it can be argued that the community as a whole has contributed to the 'development' of abandoned mines[2]. This is because we have used the products and energy derived from mining and mineral processing. Thus it would be appropriate that all stakeholders need to be involved in developing solutions to this negative legacy.

In Australia, the State and Northern Territory governments are primarily responsible for management of abandoned mines with the Commonwealth government having responsibility for abandoned uranium mines. Governments are either the land owner or by default, have become responsible for managing abandoned sites in the absence of any other party.

Receiving the James Love Churchill Fellowship has enabled me to learn about leading practice abandoned mine programs from different perspectives across a range of scales; local, regional, state, national and international.

My six week fellowship program included visits to four countries; Austria, Germany, England and Canada, five primary organizations and many others through their networks. I also attended one conference and undertook eight site inspections. During this time I interviewed 23 primary contacts and held meetings with a further 20

[2] 101 Uses for a hole in the ground, Pearman G (2009) Eden Project Post-mining alliance

people and met many others along the way. They have all inspired me and I thank them for that.

Because of the diversity and number of sources used in this study, my conclusions should be considered indicative only. It is my desire that the conclusions drawn, questions raised and recommendations made, prompt further research by relevant parties to develop and refine an effective framework for abandoned mines in Australia. This must be followed up by implementation and regular reviews of performance. The conclusions are mine as are any errors or misinterpretations.

Thank you to the Winston Churchill Memorial Trust Queensland Branch for their support and the National Board for granting me the James Love Fellowship. Thank you to James Love for leaving a positive legacy which supported my program. Thanks also to my referees, Russell Dann, Mines and Energy, Department of Employment, Economic Development and Innovation, Rockhampton and Ron McLean, SMI Knowledge Transfer (formerly ACMER) a business unit of JKTech Pty Ltd, which is the commercial arm of the Sustainable Minerals Institute at the University of QLD.

I would like to acknowledge the following key people for their help during planning of my program and feedback on specific sections of the report:

- Peter Waggitt, Consultant, Nuclear Fuel Cycle and Material Section, IAEA;
- Dr Michael Paul, Division Head Development and Monitoring, WISMUT GmbH;
- Dr Peter Whitbread-Abrutat, Senior Scientist, and Caroline Digby, Director, Eden Project Post-Mining Alliance, Cornwall England;
- Gilles Tremblay, MEND/NOAMI secretariat, Ottawa, Ontario Canada
- Gregg Stewart, Crown Contaminated Land Program, Victoria British Columbia, Canada.

Thanks to all of the people who shared their knowledge and time with me from the various organizations I visited. I very much appreciated the hospitality of the Waggitt, Edge, Gräbner, Ertle, Boman and Wels families while overseas.

Thank you to Emer. Prof. L Clive Bell, Tania Laurencont, Ron McLean and Russell Dann for review of my draft final report and to Debby Raymond for editorial advice.

Finally, I could not have undertaken this study program without the support of my family. Many thanks to my husband Justin Kassulke, children Freya and Bryan and my sister Adèle Fielding.

ACRONYMS

AMD	Acid and Metalliferous Drainage, also referred to as ML/ARD, Metal Leaching/Acid Rock Drainage – used here to include all forms of acid and neutral pH metal drainage as well as saline drainage
AusIMM	Australian Institute of Mining and Metallurgy
BC	British Columbia, Canada
CANMET	Canada Centre for Mineral and Energy Technology, within NRCAN
CC	Cornwall Council (a regional unitary council)
CCLP	Crown Contaminated Land Program, British Columbia Canada
CNSC	Canadian Nuclear Safety Commission
COAG	Council of Australian Governments
C&WD	Cornwall and West Devon, England
CSM	Camborne School of Mines, Perryn, Cornwall
GARD	Global Acid Rock Drainage, web based guideline
IBA	Internationale Bauausstellung - International Building Exhibition[3]
IAEA	International Atomic Energy Agency
INAC	Indian and Northern Affairs Canada
INAP	International Network for Acid Prevention
LMBV	Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH – Lausitz and Central-German Mining Administration Company
MAC	Mining Association of Canada
MCA	Minerals Council of Australia
MCMPR	Ministerial Council on Mineral and Petroleum Resources, Australia
MEND	Mine Environment Neutral Drainage program, Canada
NGOs	Non government organizations
NOAMI	National Orphaned and Abandoned Mine Initiative, Canada
NORM	Naturally Occurring Radioactive Materials
NRCAN	Natural Resources Canada
NT	Northern Territory, Australia
NUTP	National Uranium Tailings Program, Canada
O&A	Orphaned and Abandoned, mines
RATS	Reactive Acid Tailings Stabilization, Canada
SMCRA	Surface Mining Control and Reclamation Act of 1977, regulation of coal mines USA by the Office of Surface Mining
SMI	Sustainable Minerals Institute and SMI Knowledge Transfer, formerly ACMER, A Business Unit of JKTech Pty Ltd
SSSI	Site of Special Scientific Interest, England
UMTRA	Uranium mill tailings remedial action, USA
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPSAT	Uranium Production Site Appraisal Team
WHS	World Heritage Site (listing is undertaken through UNESCO)
WTP	Water Treatment Plant

[3] IBA are innovative tools of urban and regional planning in Germany. The acronym is a world recognized trademark defining ‘a planning path that departs from the conventional in the creativity, organization and content of its considerable efforts’.

The James Love Churchill Fellowship to study leading practice abandoned mine rehabilitation and post-mining land use in programs in Austria, Germany, England and Canada.

2 EXECUTIVE SUMMARY

My objective was to learn how stakeholders such as governments, NGOs, mining industry bodies and researchers were addressing abandoned mine management in leading practice programs overseas, and apply these principles in Australia.

The **highlights** were;

- learning from the International Atomic Energy Agency that despite limited funding, global uranium mine rehabilitation projects attract some of the best expertise to help strengthen regulation and rehabilitation in less developed nations.
- finding out how Wismut was transformed from a uranium mining company in pre-1990 Germany to a mine rehabilitation company implementing a landmark rehabilitation program.
- seeing the landscape and community regeneration in a brown coal mining region of the former East Germany where more than 20 pits are being turned into recreational lakes and new economies are developing.
- understanding how the Eden Project vision became a reality - how a localized NGO-driven project can have global benefits by showcasing leading practices through the Post-Mining Alliance.
- experiencing community-based groups working together with a mix of voluntary and paid staff to develop successful heritage tourism venues; Cornwall Council, Pendeen Community Heritage and the National Trust in a World Heritage Listed area.
- seeing the mining industry lead the way with the ambitious ‘Eco-towns’ project Cornwall.
- learning how the forthright and transparent accountability of Canadian governments at National and Provincial levels has facilitated a determined effort toward reducing historic mine legacies.
- understanding how the mining industry and governments <u>together</u> address challenges, through the National Orphaned and Abandoned Mine initiative, Canada.
- experiencing empowered project teams supported at a high level of government and allocated appropriate resourcing;
- gaining an overall sense of how different groups work toward a common vision and by that unified effort are able to; repair degraded landscapes, make them safe and accessible and go beyond the physical boundaries to develop new assets, economies and new futures.

Several common **themes** were exhibited by programs overseas. They include;

- innovation and excellence,
- strong leadership,
- clear acceptance of responsibility by governments,
- consistent legislation and regulation,
- clarity of regulatory control with no ‘grey areas’, supported by sound policy,
- networks and regular forums providing valuable connections,
- sufficient resources – money, skills and data,
- the importance of NGOs,
- the value of broad stakeholder engagement,
- long term vision - having a plan, knowing what is needed and implementing it,

- effective organizational structures with a single point of contact,
- shared focus by different stakeholders ensuring political, personal or physical boundaries become 'invisible',
- transparent performance reporting,
- clear evidence of liability reduction and creation of new opportunities,
- obstacles are overcome in a systematic manner to achieve the project vision,
- creation of landmark projects lead the way for others,
- lessons learned from abandoned mine programs are transferred to industry, governments, researchers, catchment groups and other stakeholders improving the sustainable development of mining at different scales.

In Australia we need;

- High level acknowledgement of abandoned mine liabilities by Governments, and determination to address them. This means;
  - The Commonwealth Government must show leadership by publicly endorsing the Strategic Framework for Abandoned Mines in 2010, ensuring all stakeholders are engaged, and resources are applied to support its implementation; and
  - State/NT governments must ensure they have one lead agency managing abandoned sites and stakeholder engagement.

- Lead agencies must ensure they;
  - have clearly defined abandoned mine policies;
  - have a separate team of personnel, with appropriate skills to manage abandoned mines;
  - support the human and financial resources to project manage the abandoned mine program;
  - undertake a complete inventory of their abandoned mine liabilities within 1-2 years;
  - rectify abandoned mine legacies in a defined time frame, say 10 years;
  - use risk based prioritisation systems to tackle high risks first;
  - include all aspects of sustainability, economic, environmental and social when planning projects and engaging stakeholders;
  - use expert panels with appropriate skills mix, (e.g. environment, industrial archaeology, engineering) to review larger and more complex site planning;
  - complete and make available to the public, biennial performance reports on their abandoned mine programs.
- Within one year, a review of these programs by Auditors-General and plan to review again periodically to ensure full liability accounting and performance reporting at all levels of government, i.e. Commonwealth and State/NT.
- A national forum on abandoned mine management to be lead by the Commonwealth Government in 2010 engaging all State/NT governments and all key stakeholders. Attract keynote speakers from leading practice programs/projects overseas. Use this forum to define roles, responsibilities and time frames for implementation.
- The Commonwealth and State/NT governments as well as the Minerals Council of Australia to establish an abandoned mines secretariat with multi-stakeholder advisory committee to facilitate networking on abandoned mine rehabilitation (including related contaminated land) in Australia. This must ensure links within Australia are established, as well as links to overseas networks so more can be learned about leading practices.
- More emphasis on mining heritage conservation and adaptive re-use of historic mines.

- The Commonwealth Government to initiate an awards program to acknowledge leading practice abandoned mine projects within Australia and attract innovative and unusual stakeholders to support projects.
- A training course on abandoned mine management be run within two years targeted at all stakeholders,
- An abandoned mine toolkit for Australia to be developed within 1-2 years drawing on case studies from overseas and within Australia.
- Have 100% financial assurance for mining projects.
- Ensure 'polluter pays' legislation is incorporated into regulatory frameworks for mining where they do not currently exist.
- Explore opportunities to divert a proportion of lottery funds to post-mining land uses where heritage conservation or other development will have a direct socio-economic benefit to communities.
- More catchment groups engaged in abandoned mine rehabilitation programs.

Implementation and dissemination

This report will be made available to:

- Auditors-General (all States/Northern Territory and Commonwealth);
- specific stakeholders e.g. Department of Resources, Energy and Trade, MCMPR, Abandoned Mine Working Group, SMI, MCA, AusIMM Sustainability Committee; State/NT governments and personnel managing abandoned mines;
- technology transfer providers e.g. SMI Knowledge Transfer;
- Australian Mining History Association;
- catchment groups;
- mining heritage conservation and heritage tourism organisations;
- conferences, workshops and journals, and
- the Australian community via media releases and interviews.

Corinne Unger, Environmental Consultant
Chapel Hill, Brisbane, Queensland
0417 550021 kasung@bigpond.com

3 FELLOWSHIP PROGRAM

Vienna, Austria (2 - 7 Sep) The International Atomic Energy Agency (IAEA)
International abandoned uranium mine rehabilitation and training programs for member nations. My visit included interviews over 3 days with experts in the:

- Nuclear Fuel Cycle and Materials, and Waste Technology Sections; and
- Decommissioning and Remediation Unit, Waste and Environmental Safety Section, and the Division of Radiation, Transport and Waste Safety.

Chemnitz, Germany (8 - 13 Sep) Wismut GmbH
Site inspections and interviews over 2 days focussed on rehabilitation of an historic uranium mining region in eastern Germany since reunification in 1990. Project management, technical and regulatory aspects of the following were addressed;

- tailings and waste rock rehabilitation;
- flooding of underground workings;
- backfilling of an open cut pit;
- radon management;
- safety and health aspects of the rehabilitation works themselves;
- water treatment and long term management; and
- post-mining land use opportunities and limitations.

Grossräschen, Germany (14 - 18 September) IBA-SEE conference
A 3 day conference showcasing post-reunification rehabilitation of more than 20 open cut lignite (brown coal) mines incorporating new land uses to facilitate a new identity and economy for the region following mass mine closures in the early 1990's. Presentations were also given by speakers from South Africa, China, France, England, Portugal, USA, Chile, Sweden, the Czech Republic and Romania.

Cornwall, England (20 - 26 September) Eden Project Post-Mining Alliance
Over 5 days my studies included;

- the Eden Project charity, its ongoing achievements locally and globally.;
- Clay land regeneration issues, future landmark projects and research;
- Understanding the value of Cornwall's World Heritage Site (WHS) listing;
- Mineral planning issues in relation to post-mining regeneration;
- Mining heritage and tourism;
- Local heritage regeneration in a disadvantaged community;
- Sensitive mining heritage restoration in an ancient landscape; and
- Related socio-economic opportunities – training, skills.

Ottawa, Ontario Canada (27 September - 2 October) National Orphaned and Abandoned Mine Initiative (NOAMI)
Over 4 days I learnt about how NOAMI was initiated and funded as well as other related programs and perspectives, namely;

- the Mine Environment Neutral Drainage (MEND) program;
- the role and perspectives of the Mining Association of Canada (MAC);
- Indian and Northern Affairs of Canada (INAC) legacy site remediation program;
- Natural Resources Canada (NRCAN) rehabilitation research;
- Canadian Nuclear Safety Commission (CNSC).

Victoria, British Columbia, Canada (4 - 8 October) Crown Contaminated Land Program (CCLP)
Over 3 days I learned about the specifics of a provincial contaminated land remediation program; planning, prioritisation, funding and implementation and the relationship between provincial programs and NOAMI.

4 FINDINGS

To facilitate the process of drawing conclusions from this study, I have grouped my observations for each project/program under categories of scale or level of engagement. Case studies have been grouped as follows;

4.1 Local;
4.2 Regional;
4.3 State/Provincial;
4.4 National; and
4.5 International and intergovernmental.

Within each level of engagement, findings have been further grouped into key stakeholder sectors where examples are available;

- government,
- non-government (NGOs) and communities,
- mining industry; and
- research.

The conclusions, questions and recommendations are presented at the end of each section with a brief summary of key themes and recommendations in **Section 5**.

Australian context for this research follows;

In 2003 a Workshop on "Management and Remediation of Abandoned Mines" was facilitated in Brisbane by ACMER[4]. This provided a valuable opportunity for abandoned mine stakeholders to discuss the priorities and progress within each jurisdiction as well to learn the role of NOAMI, (National Orphaned and Abandoned Mine Initiative in Canada). Several issues were raised at this workshop. In particular the need to develop an overall framework for addressing abandoned mines issues in Australia was highlighted. Also the need for management strategies, a review of funding opportunities and legislative issues was raised. All of these were needed to map out a path forward.

In 2006, an Abandoned Mines Working Group (AMWG) of the MCMPR (Ministerial Council for Mineral and Petroleum Resources) was formed with representations from those states who wanted to participate as well as the industry body, MCA and ACMER. Under the leadership of the NSW government a series of meetings of this working group were held and it is understood that an internal discussion paper was drafted. The AMWG are now preparing a Strategic Framework on Abandoned Mines. The presence of this working group, however, does not guarantee all jurisdictions are engaged nor all stakeholders. Nor does it follow automatically that the MCMPR will agree to the endorsement or implementation of the Strategic Framework. There is a need for multi-stakeholder support for such a strategy.

Over the last decade the rate at which the larger complex abandoned mines are being rehabilitated by governments is insufficient to significantly reduce liabilities within this generation. As such these programs reflect a contradiction to sustainability:

"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs[5].

[4] Australian Centre for Mining Environmental Research, Proceedings, L C Bell (Ed) November 2003 The technology transfer role of ACMER is now within the SMI.
[5] Brundtland (1987) Our common future

This ‘backlog of abandoned mines’ has an impact upon the perception of, and acceptance for, the mining industry in the community. If we are not making sufficient progress on this challenge in Australia, then we are also allowing liabilities to escalate. For example, Acidic and Metalliferous Drainage (AMD) impacts on groundwater only get worse over time if there is no control of the source. Also, heritage features become vandalized or decay in the absence of management and conservation and opportunities for community rejuvenation are also lost.

Abandoned mines present largely an historic legacy, with new mines less likely to become the responsibility of the state due to current legislative controls.

My objective was to learn how stakeholders such as governments, NGOs, mining industry bodies and researchers were addressing abandoned mine management in leading practice programs overseas, and apply these principles in Australia.

Specifically, I wished to know;

- What were the key factors that turned a collection of neglected abandoned sites into a rehabilitation program with a clear policy and vision, which was well resourced and fully implemented with tangible beneficial outcomes?
- What triggered other State and Federal governments to take major leaps forward in their abandoned and contaminated land rehabilitation programs/ projects?
- How had national initiatives supported those programs which were the responsibility of the state governments to implement?
- How had NGOs and the private sector become involved in the transformation of mining liabilities to assets, developing skills, knowledge and communities along the way?
- How had organized networks supported those working to overcome common abandoned mine challenges?
- How can we engage all stakeholders?
- What roles do catchment groups play in focusing attention on water impacts and rehabilitation solutions?
- How had successful projects extended beyond the physical boundary of the historic minesite and region to benefit communities?

4.1 LOCAL

This section describes leading practice case studies at a local level with demonstrated community benefits.

4.1.1 GOVERNMENT

Recently the district councils of **Cornwall** England, merged with the county council to form a unitary authority, Cornwall Council (CC). Several case studies at this level of government are included in **Section 4.2.1**.

4.1.2 NON-GOVERNMENT ORGANISATIONS

Before describing the local case studies from Cornwall, there is a need to provide some historical context.

Cornwall was one of Europe's earliest industrial regions with a complex and dispersed society. During the 19th Century tin and copper mining experienced exceptional growth with about half of Cornish families dependent upon extractive industries. More were influenced by its growth and decline[6].

Cornwall's regenerating economy comprises predominantly a rural population in a peripheral region, suffering from a century of decline of its primary industries including agriculture, fishing and, especially, mining. But for the beautiful coast and the advent of tourism in the mid-20th century, there would have been little future for the communities[7].

Clay mining transformed the scattered farms and granite moorland of more than 200 years ago to a series of small pits in the early 1840's. Over time pits became larger, new villages were built to house workers and mineral waste products formed conical tips (waste dumps) which transformed the skyline. This china clay industry affects over 80km^2 and during the past 30 years the local industry has undergone severe retrenchments. The current working population is about 1,000 although clay production remains high.

Eden Project
Located near St Austell, Cornwall, the Eden Project is an educational charity which promotes our connection to nature and our dependence on it for all we need. This ambitious and successful attraction with more than 1.1 million visitors/year, has been constructed in a mined out china clay pit.

There are both outdoor and indoor conservatories (including the largest in the world) known as biomes (Mediterranean and Tropical) with other attractions such as the Visitors Centre 'The Core', a shop and stage area. The Foundation Building inside the edge of the historic clay pit is the base for management of the Eden Project and leadership of outreach projects including the Post-Mining Alliance. The global role of this group is described in **Section 4.5**.

[6] Cornwall and West Devon Mining landscape, WHS Mgmt plan, 2005-2010
[7] Peter Whitbread-Abrutat, Eden Project case study (2009)

This mine rehabilitation project involved major re-landscaping to enable the Eden Project objectives to be met. Works included slope stabilization, pit floor raising, landform development and installation of drainage; construction of the biomes and development of 85,000 tonnes of artificial soils from china clay sand waste and composted wastes. Ongoing dewatering keeps the water level below the base of the pit and provides recycle water for gardens.

Funding

The Millenium Commission contributed £56m of lottery funding[8] to single out Eden as the 'landmark' project of the far South West. Other sources included the EU and Southwest Regional Development Agency, (about £50m) and £20m of commercial loans. The balance of £8m comprised; other loans, funds generated by Eden and reinvested back into the project. Eden has created over 400 full-time and 200 seasonal jobs, has 200 volunteers and has attracted over 11 million visitors, inspiring an economic renaissance in Cornwall. The project has brought £900m of incremental business into the county since 2001[8].

The success of this project has provided a 'glow' in this locality which other projects seek to have reflected in theirs. There is a strong desire for collaboration to apply what was and continues to be learned at Eden. This was very evident during my fellowship program as I met with other organizations within the region. The claylands consultation as well as the Post-Mining Alliance are examples of the broader application of what has been developed at this hub of innovation and excellence.

Community engagement

A creative community engagement approach was applied by Eden Project for Cornwall Council with a focus on post- mining land uses in the vicinity of Eden where china clay mining has been declining, causing flow-on impacts on communities. Focused on 'clay futures' a range of options for urban planning were pursued. The following, from Juliet Rose (including **photo** below showing consultation activities in a community hall), describes the rationale behind this unique and engaging process.

The purpose was to create a space for conversations about the future;

- that inspires and encourages reflection on what people want and need;
- where people feel more confident expressing their true feelings, opinions and beliefs;

- that is inclusive and would appeal to people of different ages and abilities, whilst;
- recognising that people's time is precious and that engagement should be fun! and
- creating an opportunity for communities to participate in a meaningful way contributing their stories, ideas or concerns.

Every activity included a mechanism for recording community perspectives on a specific issue of urban planning. For example, placing a pin on an aerial photograph of their town to show where they perceive the 'heart' of the town to be and to explain why.

[8] Eden Project, the guide 2009/2010

Transferable lessons[9]

The Eden Project has provided the following guidance when planning a successful and distinctive 'wow attraction';

- Include the 'unusual suspects' to develop novel approaches;
- Develop local solutions according to local circumstances;
- Employ a proven and charismatic leader;
- Engage with the local community from the start;
- Monitor key environmental, social and economic indicators from the start to determine the impact of the regeneration project at a later stage;
- Develop a vision that excites;
- Do not compromise on quality;
- Pursue constructive local employment and sourcing policies to maximize the beneficial footprint of the project;
- Nurture a positive institutional 'can do' attitude;
- Base partnership approaches on building trust and intellectual trade to develop synergy;
- Make education fun and engage visitors emotionally;
- Involve artists, scientists and so on from the start rather than retrofitting their work to the project later on;
- Be an informed client; and
- Explore how, by changing the rules of engagement, you can elicit positive responses from those whose approach is traditionally cautious and risk-averse.

The **China Clay Country Park** mining and heritage centre was established in 1975 to preserve and record the history of the china clay mining area[10]. Located within an old china clay processing plant, visitors learn about china clay (kaolin) bearing granite, how it was discovered, extracted, processed and used. An interpretive center orients the visitor prior to walking past the various historic elements of production to a lookout over two small pits, Greensplat and Wheal Martyn, which have been operating for about 200 years. A key feature of this site is the link between historic and current mining. The lookout is also a Site of Special Scientific Interest (SSSI) as it provides a good example of a stage of kaolinisation normally only seen at the bottom of a clay pit. **Photos** show an active pit from the lookout and a water wheel within the old processing plant area.

The landscape of the china clay mining area in Cornwall has several distinctive conical tips (waste dumps containing erodible yet benign, sandy/gravelly materials) such as the Great Treverbyn 'Sky tip'. When there were more of them and they were unvegetated, they were described as 'Cornish Alps'. Some vegetated tips have been retained. As one person described it, 'When I'm driving and see them in the distance, I know I'm nearly home'.

[9] Peter Whitbread-Abrutat, Eden Project case study (2009)

[10] China Clay Country Park, Mining and Heritage Centre, Visitor guide

There are also **ClayTrails** which link to the Cornish Way and The National Cycle Network. This initiative involves a number of partnerships including government, NGOs and industry[11].

Pendeen Community Heritage - Geevor Tin Mine

Towards Land's End on the Cornish peninsular is the Geevor Tin Mine with evidence of 18th century underground mining. In the West Penwith area tin and copper mining has occurred since the Bronze Age. More recently, a mining operation at Geevor extended from 1911 till 1990, after the tin price crash. Mine workings extend both under the sea and land. Cornwall Council acquired the mine over 5 years ago with input from various partners and since 2001 the site has been managed by Pendeen Community Heritage[12]. A conservation plan produced by Cornwall Council provides an overarching strategy.

Three aims were to conserve Geevor's heritage, use the site for all forms of education and to create sustainable employment. Geevor tin mine is situated;

- within an Area of Outstanding Natural Beauty (AONB);
- in the West Penwith Environmentally Sensitive Area (ESA);
- within the Area of Great Historic Value (AGHV);
- lies partly within the Site of Special Scientific Interest; and
- within the large Area of Great Scientific Value (AGSV).

Recently this area and 9 other parts of Cornwall and West Devon became part of a World Heritage Site (WHS) (UNESCO) (See also **Section 4.5**).

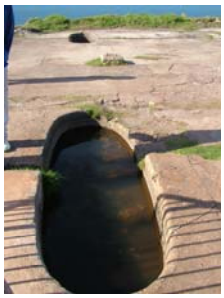
The personal nature of guided tours is a key feature of the success of this heritage tourism site. Also important has been the retention of equipment often removed during the 'fire sale' when mines close (see **photos**). Many of the guides are ex-miners providing valuable personal insights to the tour.

[11] http://www.sustrans.org.uk/

[12] Geevor Tin Mine, Pendeen Community Heritage Briefing Sep 2009, Bill Lakin Chair of Trustees

The leadership and teamwork of this community group is also a significant key to its success. The Pendeen Community Heritage group manages the site on a limited budget, raising money from entry fees, the shop and cafe. While a modern interpretive centre is located on the steep coastal hillside mine complex, most of the original buildings have been conserved in order to provide access without detracting from the authenticity eg. 'the dry' where mining clothes were hung to dry, the change rooms and washing facilities. Other important keys to success include the persistent and staged conservation work which has lead to opening additional buildings within the complex. The mill area is spectacular with its timber structures, picking belt, and heavy media separation with a demonstration of the shaking tables, all within a thin iron shed to keep out the North Atlantic wind and rain. An underground tour of 18th century mine workings, is also part of the visitor experience.

Within 500 metres of Geevor is the Levant Mine[13] managed by the **National Trust**, (also mentioned in **Section 4.4**) with a self-guided trail. Also on this site is the oldest beam engine in Cornwall and the first to be preserved and later restored by the 'Greasy Gang', a group of retired steam engineers and enthusiasts. Levant was a heritage site whilst Geevor was still operating for a while. Having learned of the relatively recent mining operations at the Geevor Tin Mine, we walked to the Levant mine, which was like walking back in time. Here it is possible to learn about more historic mining methods through interpretation of the landscape and archaeology. The National Trust engages volunteers to support its work and is a well funded and managed body through membership across the UK. A further walk around the headland takes visitors to the Botallack Mine where pre-, early and late 19th Century features can be observed as well as early and late 20th Century. **Photos** shows me with volunteers and employees of the National Trust, CC as well as Eden Project hosts. Also shown are some historic mine features.


From discussions with archaeologist Adam Sharpe, CC I learned of some of the current challenges being addressed.

- Geevor can handle larger groups than Levant and this has lead to a focus on the space in between, the biodiversity trail.
- Two sites traditionally appeal to different audiences, steam buff and old visitors for Levant, and families at Geevor. The hard rock museum at Geevor attempts to address this.
- They need to keep reviewing the balance between guided and self-guided to ensure the tours continue to meet the needs of visitors.
- Guides are expensive and it is difficult to predict numbers (ie. if it is sunny people are likely to go to the beach rather than the mine).
- Aging volunteers poses some vulnerability to sustainability of the tour.
- Short visitor season (significantly reduced winter visitors) with potential for cultural and artistic activities.

[13] National Trust Levant Mine and Botallack Mine self-guided trail brochures

- Using elements that make up the whole landscape not just a scatter of key sites (which fits with the objectives of the WHS listing) while these sites still maintain the physical and intellectual points of entry.

Keys to success of the collective attraction include:

- the mix of paid staff and volunteers;
- enthusiasm of volunteers and paid staff. Geevor staff manage this so well with visitor feedback confirming the importance of the human touch;
- during quiet times, in the winter, maintenance and works enable staff to be used and develop the sense of ownership ;
- Repeat visitation and the need to maintain high levels of word-of-mouth recommendations whilst also adding to visitor experience i.e. they know their unique selling points, human contact, historic link to guides (ex-miners now guides at Geevor enable a sense of what the mine was like to work in);
- ongoing archaeological investigations to uncover more of the site history (eg. exposing additional shafts);
- spectacular views from the top of the cliffs (and from the café) of the coastline and ocean; and
- visitors enjoy authentic 'Cornishness'.[14]

Photos: Starting the Levant Beam Engine (L) and view from the engine house of the cliffs where miners walked to work (on a rare sunny day) (R).

4.1.3 MINING INDUSTRY

Clay country Eco-town

The Eco-town initiative was launched in 2007 by the UK Government through the Department of Communities and Local Government. It was a competition to build new communities that could meet the challenge of low carbon living and act as pathfinders for low carbon living for the UK. The Eco-town competition was seen as an appropriate mechanism to forward these ambitions.

Imerys, an international industrial mineral mining and processing company, operates a significant kaolin mining operation in Cornwall. As a result of significant restructuring in 2006 an opportunity for innovative re-use and regeneration of 700 hectares of non-operational land became available.

[14] Section 4.1.2 acknowledgements: Peter Whitbread-Abrutat, Caroline Digby, Georgina Pearman, Juliet Rose and Sarah Woodruff, Eden Project, Ainsley Cocks, Cornish Mining WHS, Bill Lakin, Geevor, Lindsey Bremmell, Lindsey Butterfield, Adrian Felix, Tom Barr, National Trust, Levant and Botallack, Adam Sharpe, CC

The Imerys Clay Country Eco-town was one of over 50 projects that originally entered the competition. They were ultimately successful and Imerys' Eco-town is one of only four projects selected by UK Government in July 2009 that will now proceed to development. The project is the basis for an ambitious and innovative development that will build on previous landscape restoration work and will seek to deliver novel and effective social, economic and environmental restoration within the context of low carbon living.

Located on six key locations within the clay area the development is appropriate to the rural context within Cornwall and seeks to bolster the nearby market town of St Austell rather than compete with it. **Photos** show a mine (L) and a port site (R).

The project aims to:

- remediate old mined areas and other industrial sites no longer required by the mining company; and
- develop sustainable social, environmental and economic gain on the former mine workings through appropriate low carbon development which will act as an international exemplar for the company.

Key elements of the project will include:

- sustainable social, environmental and economic gain on the former mine demonstrating energy and carbon efficient housing;
- socially advanced town design creating a sense of place where people will want to live;
- integrated low carbon public transport systems;
- a restored and functioning landscape with significant levels of public greenspace;
- affordable Housing - 40% of the development will be available to meet this target; and
- up to 5,000 new jobs, especially in the green technologies sector

Imerys have developed a joint venture with Swiss/Egyptian consortium (Orascom) to deliver this project. This is seen as a long-term venture which may take 20 years to complete. It is a very significant project, in terms of scale and impact, in the Cornwall area. It will need to pass through all the usual planning processes with the local planning authority, CC, as well as passing key tests and sustainability standards through national Policy Planning Statements issued by the UK Government. Numerous baseline surveys have been completed and Imerys have a clear understanding of which features are most significant and need to be managed[15].

[15] Clay Country Eco-town, Summary Booklet July 2009, Imerys, Chris Varcoe presentation and Ian Davies, consultant

There are many challenges with such an ambitious project such as compatibility with existing urban areas and businesses and the need for seamless integration with existing communities. The joint venture intends to start with a 'demonstrator' that will show key elements of the Eco-town in microcosm, to learn from the challenges and success there, before they move on to the other larger sites.

4.1.4 RESEARCH

The following two case studies are drawn from presentations given at the **IBA-SEE** conference in eastern Germany. They address the importance of mining landscape for local identity and challenges of town planning near an operating mine.

A presentation by Professor David Roberston, State University of New York "Identity and the post-mining landscape: observations from the **American Mining town**" provided insights into the ways that the identity of residents is tied to the mining past and its landscape legacies. Even those posing serious threats to environmental quality can function as key signifiers of local identity - both individual and group identities. The three towns, Cokedale in Colorado, Picher in Oklahoma and Toluca in Illinois, were the focus of his research book and presentation. Professor Robertson observed that "stewardship of landscape resources requires an understanding of their emotional value". This understanding can create both conflict and opportunities for those managing abandoned mine safety and environmental contamination issues alongside historic landscape and identity values.

Anders Lundgren described the ongoing challenges of town planning at **Kiruna**, **Sweden**, "A Swedish mining town in continuous transformation", when underground mine plans and associated subsidence predictions continue to change and those changes impact directly on the town plan. He explained the need for a buffer zone around mining activities to ensure 'mental safety for people' a concept which is probably only understood by those where towns and mines are in very close proximity. Planning must consider relocation of the whole town versus relocation of key iconic structures and demolition of others.

4.1.5 CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS (LOCAL)

Conclusions

Abandoned mine rehabilitation and community regeneration projects at a local level overseas have provided the following insights;

- Landmark projects have significant local socio-economic benefits often extending to regions.
- Hubs of innovation and excellence inspire others to try new approaches.
- Project champions have to exist for successful projects to follow.
- NGOs have a valuable role in providing alternative perspectives, getting things done in a unique manner, and leading the way in engaging communities.
- Innovative community consultation is likely to lead to better outcomes particularly where cumulative impacts of mining and opportunities after mining are to be evaluated.
- Collectively engaging clusters of communities rather than one by one, project by project may overcome 'consultation fatigue';
- A creative approach to consultation can lead to creative land uses. This approach could be applied to post-operational use of quarries in urban areas, e.g. Brisbane

City Council, as well as to mines and mining regions. E.g. Hunter Valley and Bowen Basin in Australia;

- Case studies on urban redevelopment of previously mined lands within Australia may not be communicated widely. Those involved in rehabilitation of active and abandoned mines need to learn from others via a post-mining land use network so transferable lessons are learned (eg. industrial uses near Ipswich).
- Mining features and landscapes are both important to communities and need to be considered in rehabilitation where there is a perceived conflict between safety, aesthetics, rehabilitation and ongoing access.
- Mining heritage conservation should be given more attention by governments managing abandoned mine sites in Australia. If only limited effort is funded on a site, then heritage values are neglected. Heritage listing does not result in heritage conservation when governments become the owners of these assets (eg Mount Morgan). They may be seen as liabilities and simply locked up to keep people 'safe and away'.
- These same mining features may provide opportunities that are unrealised in many rehabilitation projects because of the lack of diversity in mine rehabilitation teams or inadequate resources to engage those key skills. Projects need to have capabilities which address safety, environmental concerns as well as socio-economic; such as consultation and mining heritage aspects, tourism and new businesses.
- When several mining heritage attractions support a larger vision e.g. several close together, their unity can support new economies following mine closure. Having a common vision as well as the support of many individuals, groups and councils is essential. Strong leadership and collaboration are important.
- We have some good examples of post-mining land use and mining heritage tourism in Australia but limited means to communicate what has been learnt from them. There is a need for a network and regular forum to bring together people working in abandoned mine rehabilitation (from industry, government, NGOs and research).
- Local communities need 'mental safety' by both being engaged in projects which determine the fate of historic mining areas, and also to have some certainty via a long term plan/vision.

Questions:

- What is needed to encourage innovative new land uses after mining in Australia?
- How can future bike and walking trails be linked to mining heritage sites? What networks do abandoned mine rehabilitation managers need to develop?
- Do we have an equivalent Eco-towns-type opportunity in Australia where disused mined land could be used to develop ecologically friendly (low carbon footprint) housing?
- Do we have Sites of Special Scientific Interest in Australia and if so how are these sites incorporated into abandoned mine rehabilitation programs? (e.g. specific geological features or exposures of unique lithology)
- Where are the next generation of mining heritage tour guides (paid/ voluntary) coming from once the ex-miners retire? This has relevance overseas as well as in Australia (eg Broken Hill Line of Lode). How and where is this training being undertaken?
- Are there significant volunteer resources which are as yet untapped because of lack of opportunities, such as land rehabilitation and heritage tourism?
- What other leading practice projects are there in Australia worthy of acknowledgement in this context?

- How can stakeholders support project champions who will lead innovative mine rehabilitation/post-mining land use projects?

Recommendations:

1) Establish a national abandoned mine and post-mining land use secretariat to provide strong leadership and focal point for networking and problem solving. This is needed to ensure communication of leading practice methods and innovative solutions whilst also engaging key stakeholders.

2) Australia needs more local landmark projects to bolster the socio-economic basis of post-mining communities and provide leadership within localities. We should explore how resources and knowledge can be pooled to develop excellent 'wow' attractions which are the best at what they present.

3) The mining industry councils and/or AusIMM committees to consider 'adopting' a site with significant heritage values and potential for socio-economic benefits for communities. Either a whole abandoned mine or a single feature e.g. for an interpretive centre or other structure worthy of conservation.

4) Have an annual award for 1) abandoned mine rehabilitation projects and 2) innovative post-mining land uses. Who shall sponsor?

5) Provide funding for travelling fellowships on mining heritage for abandoned mine managers, with the aim of applying this knowledge to abandoned sites in Australia.

6) Seek out mechanisms for attracting lottery funding to abandoned mine rehabilitation projects where there are direct community benefits.

4.2 REGIONAL

This section describes programs/projects which have a regional sphere of influence. Cumulative impacts of mining and the subsequent creation of beneficial post-mining land uses for communities are covered. In most instances these regional case studies demonstrate important connections between local community needs and broader national and international programs/projects.

4.2.1 GOVERNMENT

Cornwall Council (CC)
Through CC's planning process I learned how key resources are protected from development, via mapping and buffer zones. They include;

- Metalliferous;
- Aggregates (primary and secondary, the latter being waste from the clay industry);
- Building stone; and
- Clay resources.

Quarries need to be protected from redevelopment to enable important stone types to remain accessible for restoration of important historic buildings in England. The CC planning team adopt a strategic focus when considering long term access to ports and emerging demands for materials. CC have initiated several key studies to help guide the planning process (ie linking quarries to buildings and reviewing long term transportation needs and potential uses of secondary clay pit materials). From the perspective of post-mining land use there was a strong focus within the Planning and Regeneration group on protection from sterilization of mineral and quarry resources. This enables important quarries to be protected whilst enabling those of lower 'stone' importance to be made available for other uses. Useful reference materials describing policy and planning in the Cornwall region are available.[16]

Heartlands
Heartlands is an ambitious project combining conservation of industrial archaeology with community regeneration within a very socio-economically depressed community.

The impact of mining on the Cornwall and West Devon (C&WD) landscape from 1700 - 1914 was large scale. The speed at which the industry was abandoned resulted in an unparalleled relict primary mining landscape. It features more than 3,000 shafts, numerous waste tips and over 200 engine houses, together with the remains of tin and arsenic processing[17].

Half of Cornwall's output came from the Camborne and Redruth Mining District and until the late 1870's C&WD produced more tin than any country in the world. Within this mining district Heartlands is described as a 'community led project' set in Pool on 7.5 ha, managed by CC. Heartlands is located in the centre of the largest conurbation in Cornwall which has a population around 40,000.

[16] Design, operation & reclamation of Mineral Sites in Cornwall, Draft supplement planning document May 2008, and the Cornish Building Stone and Slate Guide, 2007
[17] Cornwall & West Devon Mining Landscape, World Heritage Site Management Plan, 2005-2010

The project was the recipient of the Big Lottery Fund Living Landmarks funding of £22.3m. The total funding was £29.5m and is an example of a partnership approach aimed at transforming Cornwall's most derelict urban area into an 'inspiring' cultural landscape[18]. The area is a priority within the European Union (EU) due to its low socio-economic status. (See also **Section 4.4.1**).

The Heartlands project includes a visitors centre for the Robinsons' Shaft complex and the C&WD Mining Landscape World Heritage sites[19], as well as;

- park and gardens
- childrens' centre and community building,
- new market and congregational squares,
- catering and retail,
- conference facilities,
- work spaces for artists,
- event and performance spaces,
- housing,
- workspace,
- streetscape works for Pool Village, and
- cycleways and footpaths.

One of the methods used to engage the community during construction was to build a walking path that runs along the boundary fence so the public can readily see progress. There are also weekly tours of the project for interested community members.

This is an ambitious project with many challenges. Community engagement is essential to its success. The project has been delayed from its initial time schedule, so it will be essential to keep the community informed and engaged throughout.

There is much to learn from this project as it progresses through to completion. The official opening could be seen as 'the beginning' from the community development perspective. Socio-economically depressed communities may not inherently have the necessary skills to manage such sites without training and 'capacity building'. Such programs need to start early and persist beyond the construction phase. Not only are there engineering and creative challenges in turning this concept into a reality within time and budgetary constraints, but also to ensure the community continues to feel engaged.

Heartlands, once completed, must be sustained through funding raised from facilities onsite, community involvement and ongoing CC support. These aspects have been considered during the planning phase. Stakeholder support which has brought the project to its current stage will be critical to its successful completion and realization of the project's vision.

4.2.2 NON-GOVERNMENT

The role of **Appalachian Catchment Groups** was described in a presentation by Professor Neil Korostoff, Penn State University. The focus of his presentation "USA – Western Pennsylvania the Landscape legacy of Coal" was on the role of

[18] Photo of Robinsons shaft complex inspection courtesy of Heartlands Project, Scott James
[19] Heartlands project overview document and CD, Cornwall council, Homes and Communities Agency and Lottery funded (2009)

decentralized community based restoration in mining catchments. In this region after 150 years of mining, until 1977, unregulated mining led to 110,000 historic unrehabilitated mines and 4,000km of streams sterile from acidic and neutral pH metalliferous drainage (AMD), also referred to as ML/ARD (metal leaching/acid rock drainage, including saline drainage).

"Acid drainage is one of the most serious and potentially enduring environmental problems for the mining industry. Left unchecked, it can result in such long-term water quality impacts that it could well be this industry's most harmful legacy. Effectively dealing with acid drainage is a formidable challenge for which no global solutions currently exist[20]."

Catchment groups formed as a result of growing dissatisfaction with the status of land degradation and water pollution posing significant threats to ecology. These community groups enabled funding to be made available for restoration projects. Passive wetland treatment of water appears to have been the focus of these catchment groups. Significant funding held in an abandoned mine fund by the Federal government since the introduction of legislation (SMCRA) allocated 35c/tonne as a tax on coal production. A consequence of catchment group restoration has been the return of pride and prosperity to degraded regions.

4.2.3 RESEARCH

Professor Frances Wall [21], at the **Cornwall campus of Exeter University** explained the role and evolution of the Camborne School of Mines in this region, its courses as well as future directions for; research, undergraduate and post-graduate study. CSM is one of the world's oldest mining schools with more students now than there have been for a generation.

Areas of study are focused on 1) Mining and minerals and 2) renewable energy. In summary this school:

- relocated 5 years ago to a new building which enabled an upgrade of key research equipment e.g. QEMSCAN automated SEM[22] rapid digital characterisation of particulate inorganic materials (with first use by any university world-wide), and high speed sorting facilities (mineral and waste streams);
- Maintains an experimental mine;
- Undertakes renewable energy research with a focus on specific technologies and their interaction with the distribution network using multidisciplinary teams extending into renewable energy policy and social perception; and
- Places a strategic focus on marine energy research as part of the WaveHub project.

Asked whether the CSM were involved in other environmental rehabilitation aspects associated with mining such as AMD to develop solutions to 'traditional' water pollution challenges, Professor Wall explained that there is a perception that there are already plenty of people researching these aspects and as a consequence there is a distinct shift toward the climate change challenge. This is reflected in the structure of their education and research programs. There are opportunities for

[20] http://www.inap.com.au/
[21] Head of Camborne School of Mines and Associate Professor in Applied Mineralogy, School of geography, archaeology and earth resources CSM, Exeter University, Perryn.
[22] 3rd generation mineral analysis equipment pioneered by CSIRO and Scanning Electron Microscope

abandoned mine rehabilitation solutions to incorporate alternative energy in post-mining land uses or within the rehabilitation project itself.

At the **IBA-SEE** conference in Germany, Professor May Hermanus, Director: Centre for Sustainability in Mining and Industry (CSMI) in **South Africa** described research undertaken to develop a locally relevant guideline for socio-economic (SE) aspects of mine closure. This is focused on a major coal mining district where mines are destined for closure within the next decade and closure will take place in a new policy setting in which abandonment is not permitted.

The legal baseline for social impact assessment (SIA) is limited because the legislation is relatively new and the core level of technical expertise within government is low. There are unequal partners ie. Companies can engage more expertise than government and communities are very disadvantaged, relying heavily on NGOs and volunteers. Changes in company ownership have negatively impacted community confidence in engagement and planning processes.

Guidance will be provided on;

- SE aspects of closure policy;
- How to map SE activities against the project life cycle (check status tool);
- Mine closure planning via a process guide for implementation; and
- tools to implement such plans.

From the **IBA-SEE** conference: Prof. Dr. Jiang Chang, Professor of the China University of Mining and Technology (CUMT), described the current situation of energy production and consumption in China in which coal is important. After describing the history of coal mining regions and regulation in China, Prof. Chang explained that since 2006 China had ensured industry was more responsible for rehabilitation with the Ministry for Soil and Natural Resources responsible, down to District level. Having studied in Germany Prof. Chang explained that similar instruments are being introduced in China. He noted that environmental awareness was growing around 1989 – 1995. Some voluntary rehabilitation started to be undertaken around this time. New regulatory requirements address such issues as ‘polluter pays’; precautionary principle; rules for mine development plans; and that all plans must include rehabilitation.

This issue is important for China not only to overcome land scarcity but also to bring together the sustainability principles. Professor Chang explained what is missing: comprehensive information on sites; clear responsibility for post-mining areas; and cross-border planning.

While there is funding and clear responsibilities for rehabilitation of new mines under new regulation, there is still no one responsible for old mines. Urbanisation has made this worse with a need for common planning targets such as masterplans and smaller scale plans. He explained that “having a view of the goal is halfway”.

4.2.4 CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS (REGIONAL)

Conclusions;

- Within the European Union regions are able to access millions of dollars for mining heritage conservation projects in particularly depressed communities where there is a focus on providing new economies and a community focal point.
- Lottery funds have also been made available to support such projects.

- Collaboration and community engagement are essential to success of leading practice project.
- Protection of quarry and mineral resources is a universal goal of governments to ensure ongoing access and provide long term royalties/income. Planning processes are able to do this whilst also enabling some sites to be redeveloped for alternative land uses.
- Where community catchment groups have provided strong and persistent leadership, these groups can change government policy by drawing attention to key issues. We need to further develop this expertise, by education and consultation as well as acknowledgement of its value in Australia.
- Long term vision is required to consider cumulative impacts on mining regions of mine closures and future uses of these landscapes.

Questions;

- Catchment groups are able to leverage funding for abandoned mine rehabilitation so how can we increase involvement of such groups in abandoned mine catchments in Australia?
- Are regulatory authorities sufficiently well resourced to facilitate long term planning and development of a 'vision' for post-mining landscapes where there are multiple mines and cumulative impacts? If not, how can we build capacity?
- How is urban planning incorporated into post-mining land use where these mines/quarries are close to urban areas? Are state and local governments working together on this?
- Are we limiting the opportunities for innovation in post-mining land uses in Australia because of a lack of awareness and connectivity through existing networks?
- Are we (any stakeholders) developing socio-economic guidelines to help mining regions plan for closure?
- Do we have any regional opportunities for collaboration on water treatment to develop more sustainable solutions for AMD waters than lime dosing?
- How can we turn a proportion of lottery funds to benefit communities through abandoned mine rehabilitation projects?
- How are emerging sustainability issues and opportunities for abandoned mines identified, research initiated and funded?
- How are findings communicated now that the former point of contact through ACMER has become embedded within JK Tech and residual projects are being undertaken by other organizations e.g. CMLR and UWA?
- Who is undertaking the more strategic or regionally focused research such as cumulative impacts of mine closure, risk assessment tools for closure planning which also address socio-economic opportunities, green energy, sustainable water treatment solutions and so on?
- Are we doing enough AMD research and are we learning from past practices in Australia to address the continuing challenges for mine closure both in industry and abandoned sites? This includes performance of covers in tropical environments, wetland performance in the wet-dry tropics, post closure monitoring, comparisons between predictive modeling of mine water quality vs performance.
- Will the group who were ACMER, now JK Tech be able to sustain an active involvement with INAP (International Network for Acid Prevention) as a Global Alliance partner under the new arrangements within the SMI? Are there other roles beyond training courses, which need to be addressed and who will address these?

Recommendations;

1) Evaluate funding opportunities for regionally significant abandoned mine rehabilitation with potential community redevelopment opportunities.

2) Ensure regionally significant projects fully engage stakeholders, have a clearly defined vision and have strong leadership.

3) Use project leaders from these and other leading practice case studies as invited keynote speakers in Australian conferences to help communicate how these socio-economic challenges have been addressed and how visionary new land uses can be created.

4) Funding of travelling fellowships for community catchment coordinators to travel within Australia and/or overseas would help to empower these groups so they can apply this knowledge to abandoned site rehabilitation projects in Australia.

5) Research is needed on cumulative impacts of mine closure and post-mining land use.

6) More research is needed to analyse mining projects where closure did not achieve the objectives set. Such an analysis should address not only the impacts on the environment but also on communities. The mining industry and governments need to learn from this research to understand the causes so they are not repeated.

4.3 STATE

This section describes leading practice case studies at a state/provincial level.

4.3.1 GOVERNMENT

This section refers to the case study of the **Crown Contaminated Sites Program** (CCSP) of British Columbia, Canada (Victoria, BC), and within that program, the **Britannia mine**. This section is based on information from; Gregg Stewart (Manager), Joanna Runnells, Geoff Sinnett, Katherine O'Leary, and Chantelle Abanilla (CCSP), Gerry O'Hara (Golder – Britannia water management) and Dr John Errington (rehabilitation aspects of mining regulation in BC).

Following the federal government Auditor General's report (see **Section 4.4.1**) the Provincial Auditor General for BC also undertook an audit[23]. The governance of provincial contaminated land liabilities, including mines, was reviewed in this audit.

The BC Auditor General noted that the province (92% of which is Crown Land) did not have an adequate program in place for managing its contaminated sites and is not adequately accounting for its performance.

Significant improvements were required in three areas[24];

1) *The foundation needed for a sound program is lacking– Ministries and agencies are not being guided by clear direction and roles and responsibilities are not defined.*
2) *There are significant gaps in the information ministries and agencies need to develop management plans and make resource allocation decisions. As a result few management plans are in place and no government–wide plan exists.*
3) ***Without a clear, coordinated program for guiding contaminated site management activities, ministries and agencies are unable to account in a meaningful way on their progress in dealing with the risks and liabilities posed by contaminated sites.***

From this audit the Ministry of Agriculture and Lands (MAL) established the CCSP as the lead agency. MAL, the Crown Land owner and other Provincial ministries are subject to the *Environmental Management Act* (EMA). The Ministry of Environment ensures these provisions are administered on private and public land. Abandoned mines are a significant component of the contaminated land inventory.

Policy for the CCSP was approved in 2004[24] to Identify, prioritize and remediate sites based on risk to human health and the environment and only those historic contaminated sites where there were no identifiable responsible persons.

CCSP Components include;

- Program Policy;
- Provincial Contaminated Sites Committee (PCSC);
- Site Prioritization;
- Data Management and Site Inventory; and
- Reporting

[23] Office of the Auditor General of British Columbia, Managing Contaminated Sites on Provincial Lands, 2002/03 report
[24] Gregg Stewart's presentation

The Policy was developed with the PCSC. It outlines a risk-based framework for a coordinated and consistent approach.

Provincial Contaminated Sites Committee;
- Ministries with resource management responsibilities for Provincial lands, and those with a related central agency role; and
- Chaired by Ministry of Agriculture and Lands.
- PCSC provides input into the development of various Program components, such as Policy and;
- quarterly committee meetings.

The process for Site Identification, Prioritization and Evaluation follows this sequence:
1. Site identification,
2. Site status (to determine if it is the responsibility of the Crown or another land owner, and whether a prior land user is responsible for site remediation),
3. PSI (preliminary site investigation),
4. risk ranking,
5. Stage 2 PSI, DSI (detailed site investigation), risk assessment,
6. Remediation Plan, and
7. Implementation.

The CCSP relies upon robust data management which includes a consolidated repository of information for management, accountability and reporting as well as planned integration with other land management systems.

Drawing upon province-wide databases which comprise the Historic Mines Sites Atlas include:
- MINFILE: location, size and type;
- Population density and distribution;
- Road network;
- Points of Diversion and Water Wells;
- Hydrology, Community watersheds;
- FISS Fish species information; and
- Listed Species, Wildlife Habitat Areas.

Reporting is via the following mechanisms;
- Annual Financial Report;
- CCSP Biennial Report; and
- Website[25]

A summary of expenditure is shown below:

	BUDGET	**$ million CAD**
CCSP Administration	2005/06	21.6
	2006/07	23.1
	2007/08	24.1
	Booked Liabilities	219.5
	Expenditures to date	89.7

[25] http://www.agf.gov.bc.ca/clad/ccs/index.html

The CCSP Risk Ranking Methodology has as its goal "to develop a scientifically based, defensible and systematic methodology for the evaluation and ranking of priority Crown contaminated sites based on potential risk to human health and the environment."

The **Britannia minesite** is located on mainland British Columbia on the eastern shore of Howe Sound about 50 km north of Vancouver on the road to Whistler, one of the Winter Olympics venues for 2010. This case study demonstrates one of the larger and more complex abandoned sites managed within the CCSP and is the site I inspected during my program.

This copper and zinc mine was in operation for about 70 years until 1974. The government of British Columbia describes the mine site as, "one of the largest metal pollution sources in North America".[26] Some mine facts;

- Mine Site Area: 36.5sq. Km (>9,000 acres);
- Orebodies worked: 7;
- Working life of Mine: 70 years;
- Mining methods: open pit, gloryhole, open stoping;
- Ore produced: 48 million tonnes (peaking at 2 million tonnes/year in early 1930's);
- Mineralogy: mainly pyrite, with secondary chalcopyrite and sphalerite; and
- Length of underground workings: >80km

Prior to CCSP intervention contaminated water drained to Howe Sound:

> *Inside Mount Sheer, 210 km of abandoned mine workings act as conduits for rain water and snowmelt that enter open pits at the summit and flush out of a portal located at the base of the mountain. The acidic metal-laden effluent, which is acutely lethal to fish, is channelled to a submerged outfall and discharged, untreated, into the fish-bearing waters of Howe Sound[27].*

The CCSP determined that the following intervention was required and these have been implemented;

- collection of acid mine drainage through a collection plug underground;
- treatment of the acid mine drainage and contaminated groundwater at a treatment plant (WTP);
- control of discharge of contaminated groundwater;
- prevention of the formation of acid mine drainage in part by rerouting uncontaminated surface waters; and
- assessment of contaminated sediments at the outfall on Howe Sound.

Public-private partnership

In January 2005, the Ministry of Agriculture and Lands signed a 21-year project agreement with EPCOR Britannia Water Inc. to design, build, finance and operate a mine water treatment plant. The plant began full operation in January 2006. The treatment plant will have to operate indefinitely and will produce sludge each year that will need to be disposed of. The B.C. government-EPCOR agreement is an example of a public-private partnership promoted by the B.C. government[27].

[26] Britannia Mine Remediation Project, MAL Site Tour – October 6, 2009, G O'Hara & T Johnson .ppt
[27] Dealing With Mining Legacy ─ Some Canadian Approaches by Diana Valiela and Christopher G. Baldwin April 16, 2007, Rocky Mountain Law Foundation course, Argentina

EPCOR[28] provide a snapshot of water quality of influent and volumes treated for 2008. Average concentrations in mg/L were: Al 16, Cd 0.086, Cu 13.65, Fe 0.60, Mn 3.5 and Zn 15.17. Total flows were: mine workings 3.8 ML, groundwater 74,411 m^3, Plant flow 3.8 ML and Bypass flow 1,258 m^3.

The government has provided indemnification for environmental liabilities to companies who are successors to the previous mine operators in exchange for $30 million to partially fund the reclamation project [27]. Public participation in the early years of the Britannia clean-up consisted of opportunities to attend public meetings regarding project proposals and, as provided by legislation, opportunities to comment on, and appeal, applications of the government for effluent permits. Public notices and progress reports are made available in the Britannia homepage. Public participation is a major feature of a recent community redevelopment project and a project which proposes two complementary components: a historical/tourism attraction and a mining innovation centre of excellence. The innovation centre would be complemented by an initiative by the Centre for Environmental Research into Mining, Minerals and Materials (CERM3) at the University of British Columbia to establish a dedicated environmental and mining research centre[27].

Photos above show the WTP (L) and interpretive panels (R) within the visitors centre located in the building behind the WTP. School and other groups visit this WTP for tours. During the site inspection a presentation was given by Gerry O'Hara from Golder Associates followed by a mine tour accompanied by the CCSP team and Britannia Site Manager Terry Johnson and Senior Plant Operator, Ian McKinnon, EPCOR. The tour included the 4100 level plug underground, WTP and Jane Basin (glory hole and sludge disposal), groundwater management system, foreshore protection and marine ecosystem recovery. **Photos** below show the mining heritage centre (L) and sludge disposal (R).

[28] EPCOR Water Services, Annual report , Britannia Mine WTP, February 2009

The most impressive aspect of the CCSP program as an example of a Provincial abandoned mine program is the strong leadership shown by;

- the BC Provincial Auditor-General to identify key inadequacies in contaminated site management, and
- the BC Government who turned those recommendations into action via the CCSP.

The CCSP is effective because the team;

- Has a systematic method for gathering and reviewing relevant province-wide datasets to identify sites which fall within their area of responsibility; and
- Are able to identify key risks to be managed, acquire funding, manage contracts and sub-projects and communicate performance and progress.

At the Britannia site the CCSP continues to achieve the project objectives due to;

- Identification of the key risks;
- formulation of a clearly defined strategy with measurable objectives;
- A successful public-private partnership to operate the WTP;
- Inclusion of a visitors centre when the WTP was constructed to provide access to the site whilst also educating the community on causes and treatment of AMD; and
- involvement of community and other stakeholders in the process of site rehabilitation.

Finally, visible recovery of the marine environment provides the broader community with evidence that the project has been, and continues to be, successful (see **photos**).

Other provincial audits of abandoned mine programs exist (eg. Manitoba and Ontario) and provide further perspectives:

Manitoba's Auditor General report titled "Environmental Audits" was prepared in November, 2005[29]. This report included contaminated sites on Crown Land and also addressed Orphaned and Abandoned mines which are not on Crown Land. Similar observations were made regarding the limitations of government accounting of liability and reporting on performance.

“Our review was initiated in response to evolving changes to government financial reporting standards. By March 31, 2006 the Province of Manitoba and all senior governments in Canada, will be required under the Public Sector Accounting Board (PSAB) of the Canadian Institute of Chartered Accountants (CICA) to accrue and disclose its environmental liabilities. Therefore, we reviewed the processes in place

[29]Available on the Manitoba Office of Auditor General website: http://www.oag.mb.ca/reports.php

for the Province to be able to accurately identify and, where required, estimate the cost of environmental remediation for which it was responsible."

The AG noted that the responsibility for Orphaned and Abandoned mines (O&A) was not clearly defined. "The Province is not legally responsible for remediation. However, officials recognise that in the absence of a responsible party, the Province will, in all likelihood, be responsible for remediation."

Incomplete estimates were available for O&A minesites ($61.5 million) and it was acknowledged that as more site assessment work is undertaken the liability may increase. It was noted that undetected sites could exist, responsibility was not clearly defined and potential liability of the Province was not adequately identified.

Following this review the government undertook an audit of contaminated sites in 2007, (not including mines). In March 2009, a follow up Auditor General's report[30] noted that all recommendations had been fully implemented. Of relevance here in particular are representations from the Department of Science,Technology, Energy and Mines addressing the following:

> Recommendation 13: That 'Mines' develop a documented program to address the issue of O&A mine sites which could include:
> - Conducting a comprehensive inventory of sites (improve on knowledge to date);
> - Assessing the need for remediation of identified sites;
> - Identifying the legal owner and determining if they can carryout remediation;
> - Prioritizing sites in need of remediation where no legal or financially viable owner can be identified; and
> - Addressing the environmental health and safety risk and costs of not remediating O&A sites.
>
> Recommendation 14: That the status of O&A mine sites be regularly reviewed to ensure the timely update of information.
>
> Recommendation 15: That 'Mines' ensure that complete O&A mine site information and the related financial estimates of environmental liability are prepared and submitted annually to the Comptroller's Office of Finance for the recording and disclosure of environmental liabilities.

Ontario's Auditor General's reports[31] refer to abandoned mines in 2005 and 2007 and possibly earlier audits as well.

Mining Regulation in BC

Whilst in Victoria at the CCSP office I met with Dr John Errington, former Deputy Chief Inspector of Mines of BC and a Mine Reclamation expert for a brief overview of the Health, Safety and Reclamation Code for Mines in British Columbia, which addresses how mine rehabilitation is regulated in BC.

Mine reclamation legislation was enacted in BC (and Alberta) in the late 1960's with other provinces following that, some as recently as the 1990's. The BC ARD guidelines (1998) have been referred to by other provinces in their legislation. BC provided early regulatory guidance which other provinces referred to, when developing their own legislation and policy.

[30] Office of the Auditor General, Manitoba (2009) Follow-up of Previously Issued Recommendations
[31] http://www.auditor.on.ca/en/reports_2005_en.htm

Financial assurance
Regarding financial assurance for rehabilitation from companies, the Ministry (EMPR)[32] security policy for any mine (new /existing) in British Columbia seeks to provide 'reasonable assurance' that government funds will not be needed for mine reclamation. Reasonable assurance did not mean full bonding however, the Ministry aimed to get full bonding for high risk sites and those likely to require long term treatment. Most of the coal companies were regarded as financially secure so the bonding was quite low. Many of the smaller metal mining companies were bonded for as much as was possible. Now that more information is available on the costs of full rehabilitation, it is likely that bonds will increase. "It is easy to get financial security from the mines that you don't need to and difficult for the rest" is perhaps an observation applicable to many mining regulatory contexts.

At a minimum, detailed costing should be provided for the first five years of mine operation, the projected point of maximum reclamation liability during the life-of-mine, mine closure, and following mine closure. In the case of particularly long lived mines, costing projections may also be requested for every fifth or tenth year through the projected life of the mine. Companies are required to use a generic spreadsheet for consistency[33]. Within this spreadsheet is a requirement for Capital costs for AMD control and operating system costs for AMD control. Also required is a post closure worksheet to ensure post closure costs are captured.

4.3.2 CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS (STATE)

Conclusions;

- Abandoned mines on crown land are defined as 'contaminated land' in Canada whereas in Australia contaminated land doesn't generally include abandoned mines but tends to address 'sites contaminated by chemicals above background levels' but not weathering products of rock at mines (AMD). Each jurisdiction needs to be looked at individually in Australia for their definition of contaminated land.
- 'Polluter pays' legislation may exist for contaminated sites in Australia but not abandoned mines. This requires follow-up to understand why in BC it is possible to track down and seek funds from past mining companies to support rehabilitation in some instances.
- Orphaned and abandoned (O&A) mines are those on other lands which also come into the possession of the provincial governments by default;
- The need for full accounting of liability by Provincial governments as a requirement of accrual accounting was a fundamental trigger changing the way legacy sites were evaluated and rehabilitation resourced.
- The Auditor's General reports (for several provinces) provided clear and decisive reviews which highlighted the inadequacy of contaminated site/O&A mine liability accounting and performance reporting. Recommendations made were well focused. The subsequent provincial government action swiftly rectified inadequacies and the programs which resulted have clearly defined leadership, policies and roles. They also produce regular performance reports. All information is readily accessible to the public and other stakeholders via the internet. There is a high level of transparency.
- Whilst it is likely that there have been past reviews of abandoned mine governance within each jurisdiction of Australia, it is not possible to find these reviews in one document or study. One example is the Keliher report for the

[32] http://www.empr.gov.bc.ca/Mining/ProjectApprovals/Pages/ReclamationLiabilityCostEstimates.aspx

Premier of QLD in 2007[33] which made two recommendations with respect to responsibility for existing and new abandoned mines as well as the roles of a senior executive level inter-departmental management committee.

- The cost estimation tools provided by the BC government (for operating mines) is very detailed and places emphasis on capital and operating AMD costs of closure showing a risk based approach to cost estimation for financial assurance. Decades of heightened awareness of AMD legacies has contributed to this.
- Financial assurance should aim to achieve 100% of rehabilitation liability of minesites under current regulations. Many jurisdictions in Australia still do not require 100% FA from mining companies. Also, it is possible for a large company to transfer liability to a smaller company which does not have the capability or understanding of the complexities to undertake leading practice closure principles. If that smaller operation fails, the liability is transferred to the State. This is often when the inadequacy of the FA is realized.
- Public-private partnerships work well for long term management of mine water treatment, freeing up government abandoned mine project managers to assess and rehabilitate other sites.
- Having a visitors centre incorporated into the WTP adds community value to an otherwise expensive component of the project whilst supporting the role of the heritage centre and its development of tourism.
- Legislation needs to be amended in some jurisdictions in Australia to regulate abandoned mine rehabilitation.
- Risk management of abandoned mines is an area where more training and networking is needed in Australia.

Questions;

In the context of the AG's reports in Canada, have there been comparable audits of Australian programs to determine if each jurisdiction (States/NT/Commonwealth) has;

- established an adequate governance framework;
- gathered appropriate information to develop management plans and to support resource allocations;
- 'polluter pays' legislation to track ownership of inadequately closed mines to seek funding to rectify problems, rather than have liability transferred to state, and
- accounted adequately for its overall performance.

For each state/NT;

- Is there a clearly defined lead agency?
- Is there a robust policy?
- Have sufficient resources (people and money) been allocated to fully quantify liabilities and manage site rehabilitation, in a reasonable time frame?
- Are these people allocated 100% to abandoned mine functions or are they expected to also undertake other functions (such as regulatory or regional management roles)
- Has the department undertaken a complete inventory of abandoned mine/contamination liabilities within the state/territory?
- Does sufficient knowledge exist regarding abandoned minesites to make decisions about long term management and rehabilitation?

[33] Dr Leo Keliher, Chairman, Service Delivery and Performance Commission, Roles and Responsibilities of The Department of Natural Resources, Mines and Water, Environmental Protection Agency and Department of Primary Industries and Fisheries February 2007 p35-36

- Is there a risk assessment method used to prioritise abandoned mines (including areas of shafts) for site assessment, rehabilitation and monitoring?
- Is there a priority list which the state/territory is working through systematically?
- How are stakeholders including communities engaged in this process?
- How is conservation of significant heritage values resourced within the planning process?
- Are expert panels used to provide independent and external advice on risks, priorities and rehabilitation methods?
- Is it possible to use expert panels in lieu of regulatory frameworks to provide independent review and expediency whilst also making planning and implementation processes more transparent.
- How is performance reported and made accessible to the public, regarding funding and progress (for environmental, financial and social aspects)?
- Are those states/NT which do not require 100% financial assurance for mines in Australia moving toward achieving this in a reasonable time frame?
- Is NSW the only jurisdiction which supplies a template for costing? Is this optional or mandatory? It still may need the application of risk assessment to ensure sufficient effort is put into costing high risk aspects.
- How can all stakeholders be engaged in State abandoned mine programs?
- Is there a link between the SMI risk management expertise and abandoned mines?
- Who will develop improved risk management tools for abandoned mines which consider the full suite of risks associated with them, beyond safety and environmental and reputational risks? Tools need to also address beneficial opportunities and socio-economic development in the broader community.
- How do government contaminated site and abandoned site[34] managers network within Australia? Which forum brings these groups together as there are many potential project management and technical issues in common? Are there systems in place within contaminated land management which could benefit abandoned mine programs and vice versa?
- Re-mining and/or reprocessing of previously mined sites can provide successful ongoing uses for mines. The consideration of this must be part of any rehabilitation strategy. A well developed plan for the site which considers this option will help to turn this into a reality. Governments need to work hard on maintaining sites, reducing liabilities and ensuring site risks are well understood while this option is explored. Governments must ensure they provide sufficient resources to manage such processes. Waiting for a company to come and re-start the mine should be well justified and not simply an excuse to delay intervention.
- Do current regulations allow for mining companies to consider turning their mine into a 'wow attraction' deviating from the proposed landscape and land use in the EIS? What are the limitations in Australia?
- How can we make the various barriers to cooperation, become invisible? Such as industry vs government, Commonwealth vs States/NT, one state vs another (cross-border barriers), NGO vs government?

Recommendations;

1) Auditor's-General of each state and the Northern Territory within Australia need to undertake audits of those state/territory programs for managing abandoned mines to assess whether these programs are adequately accounting for both;

[34] 'Abandoned' is used here to include all types of inactive mines which end up being the responsibility of governments whether on crown land or not.

a) liabilities; and
b) performance.

2) Audit the progress of the Queensland government in its implementation of recommendations 12 and 13 of the Keliher report (2007).

3) Compare the findings of the Auditor-General's report[24] on BC contaminated sites management with abandoned mine programs in Australia. Determine if the same inadequacies exist here; They were;

    a. *The foundation needed for a sound program is lacking– Ministries and agencies are not being guided by clear direction and roles and responsibilities are not defined.*
    b. *There are significant gaps in the information ministries and agencies need to develop management plans and make resource allocation decisions. As a result few management plans are in place and no government–wide plan exists.*
    c. *Without a clear, coordinated program for guiding contaminated site management activities, ministries and agencies are unable to account in a meaningful way on their progress in dealing with the risks and liabilities posed by contaminated sites.*

4) Ensure 100% financial assurance for mine rehabilitation liability to reduce the likelihood that States/NT inherit more abandoned mines in the future.

5) Ensure 'polluter pays' legislation is in place for Australian mines and contaminated sites.

6) Develop a strategy which encourages inter-state cooperation and sharing of knowledge/expertise.

7) Overcome the barriers between the Commonwealth and States/NT, and industry and governments to work cooperatively on solutions (with reference to the NOAMI model).

8) Consider including a visitors centre at (AMD) water treatment plants as a method of adding value to the community benefit of such projects.

9) State/NT governments should consider public-private partnerships to operate WTP's to free up personnel to manage other aspects of complex sites and to evaluate other abandoned sites within their inventory.

10) Review the value of networking between contaminated site and abandoned site managers between State/NT governments in Australia as they are often managed by different departments.

11) Develop improved risk management tools for abandoned mines which address the full suite of sustainability issues.

12) All states/NT to produce biennial performance reports on abandoned mine programs/projects detailing objectives, risk assessment methods, consultation and progress toward achieving objectives.

4.4 NATIONAL

This section describes national frameworks and projects which address the challenges of abandoned mines whilst also considering beneficial post-mining land uses. Also included are national initiatives for networking and solving of problems of importance to all post-mining areas irrespective of state/province jurisdictions or government-industry-NGO boundaries.

4.4.1 GOVERNMENT

This section will describe government **frameworks** for managing abandoned sites (Canadian federal government, INAC, CNSC and English Partnerships) followed by specific case studies where **government owned companies** (Wismut and IBA Fürst-Pückler-Land and LMBV) were established to implement major projects.

CANADIAN FEDERAL GOVERNMENT

The report of the Federal Auditor General in 2002[35] '(AG report') reviewed progress on contaminated sites (including abandoned mines) since 1995 and 1996. Answers were sought on the following. Does the federal government have a;

- complete inventory of the sties it owns or manages that are contaminated?
- full picture of the risks the sites pose and the likely cost of dealing with the sites?
- management framework for dealing with these sites that includes a long term action plan for cleaning up the worse sites in order of risk?

Key findings were that the federal government had failed so far to address the issue adequately and after 13 years it still did not:

- know how many of its sites are contaminated;
- have a full picture of the risks to human health and the environment and the likely cost of dealing with (cleaning up or managing) the sites;
- have a ranking of the worst sites in order of risks;
- have long term, stable funding to manage the problem effectively; and most important,
- have firm central commitment and leadership, including an action plan for dealing with the higher-risk sites in a timely manner.

A sample of key messages from the AG report of relevance to all mine regulators and abandoned mine managers are included below.

"The Auditor General noted also that the federal government could appear to be applying a double standard (one for industry and one for government)….. and the current rate of spending was not going to achieve sufficient progress. The government says it is managing its fiscal deficits to avoid leaving a burden for future generations, but its failure to deal with the environmental legacy of contaminated sites in its own backyard passes on another burden".

Insufficient financial assurance was collected from mining companies to cover the eventual costs of cleanup. "The Department says its message to the mining industry is now loud and clear: 100 percent financial security is part of the cost of doing business in the North. An inadequate security deposit means no mine. On behalf of

[35] Commissioner of the Environment and Sustainable Development of the House of Commons (2002) Chapter 2 - The legacy of Federal Contaminated Sites, and Chapter 3 – Abandoned Mines in the North

all Canadian taxpayers, Indian and Northern Affairs Canada needs to continue its efforts to resolve the current situation and ensure that it does not happen again."

From the AG report concluded: "The Department's challenge of addressing the problems of northern abandoned mines is two-fold:

- cleaning up the environmental mess it has inherited from the past; and
- ensuring that mining companies operating in the North pay for the cleanup of the environmental problems they create now and in the future."

These findings were significant as they ensured there was a turning point in the nation's approach to abandoned mines. By accounting for federal liabilities and seeking comparable information from the provinces, many of the Provincial governments followed with their own Auditors-General reports (eg British Columbia, Manitoba and Ontario). A case study on British Columbia was included in **Section 4.3.1**.

NOAMI, CANADA

"Canada is well known for establishing multi-stakeholder initiatives to address issues of national importance. Their model of cooperation among industry, various levels of government, NGOs and Aboriginal Canadians is used nationally and internationally. NOAMI is a good example of how a collaborative approach to the legacy of past mining practices can advance the objectives of sustainable development." [36]

The **National Orphaned** and **Abandoned Mine initiative** (NOAMI) takes the form of a Secretariat, based in the Federal government offices of Natural Resources Canada (NRCan) in Ottawa and a multi-stakeholder advisory committee. Funded by contributions from federal, provincial and territorial governments, the Prospectors and Developers Association of Canada and the Mining Association of Canada (MAC) it provides a valuable network for those managing orphaned, abandoned and contaminated sites. Support was about $100,000/yr initially and increased to $350,000/yr in 2005. The **photo** shows me with G Tremblay and C Hogan (of the NOAMI secretariat) and E Gardiner (MAC).

NOAMI was created in 2002 in response to recommendations of a multi-stakeholder workshop on abandoned mines. NOAMI is guided by an Advisory Committee that brings together representatives from the Canadian mining industry, federal, provincial and territorial governments, non-government organizations and Aboriginal Canadians (ie Indian, Inuit and Metis Peoples) and reports progress to the annual Mines Ministers' Conference via the Intergovernmental Working Group (IGWG).

Five task groups undertake in-depth analyses of issues and provide recommendations and advice to the committee. These task groups focus on:

- Information gathering/inventory;

[36] NOAMI 2002-2008 Performance Report (2009)

- Community involvement;
- Legislative and institutional barriers to collaboration;
- Funding approaches; and
- Jurisdictional legislative reviews.

NOAMI Guiding Principles (2009 performance report) underpin the terms of reference for activities of the National Advisory Committee for its duration:

1. *The remediation of orphaned and abandoned mine sites must be based on concern for public health and safety, respect for ecological integrity, and sustainable development;*
2. *All work currently ongoing with respect to inventory building and remediation must continue to be based on sound science and good communication among all parties;*
3. *Work toward eliminating future abandonments must continue, including the tightening of regulatory approaches;*
4. *Implement the 'polluter pays' principle;*
5. *Targeted end-use and reclamation standards must be acceptable to local communities;*
6. *Although the objective must be comprehensive reclamation of all sites, the approach must be cost-effective and based on an acceptable method of prioritizing sites;*
7. *Transparency and disclosure must be present in all decision-making processes;*
8. *Encompass the notion of 'fairness' in all endeavours.*

Task groups include members of the Advisory Committee and other leading experts from various organizations. The leader of each task group is a member of the Advisory Committee.

Two people (and administrative support) manage the Secretariat which also coordinates the activities of a parallel technology-based program, MEND (Mine Environment Neutral Drainage).

MEND was the first multi-stakeholder international program developed to address the liabilities associated with acidic drainage. The MEND model of co-operation was adopted by other programs to address issues of national importance, including NOAMI.

History leading up to MEND: More than twenty years ago acidic drainage was beginning to be recognized as a serious issue with extensive liabilities that had not been accounted for. In Canada there had been a tradition of institutional collective approach to problem solving. From this mould, the National Uranium Tailings Program (NUTP) was formed in 1982.

National Uranium Tailings Program (NUTP) – NUTP was focused on uranium tailings, the primary concern being the isolation of low levels of radioactivity. This was a five-year research program, which ended in March 1997, and studied the ways to predict the effects on the environment of uranium mill tailings over the long term. The work was divided in three key areas; Modelling, Measurements and Disposal Technology. Approximately 100 research reports were produced over the life of the program. However the research concluded (as company owners had already stated) that acid generation from residual sulfides in Ontario tailings was the real concern. This realization combined with the concerns by base metal and gold mining companies and government agencies led to the establishment of the **Reactive Acid**

Tailings Stabilization (RATS) task force, which issued a report in 1988 which set out a 5-year research program[37] that was to cost $12.5 million.

Studies were conducted to determine the extent of the AMD problem in Canada. In total some 12,000 hectares of AMD generating tailings and 350 million tones of waste rock were identified. The sum of these sites was predicted to cost in excess of $1.5 billion over 15 years to rehabilitate. Following mining, many sites continued to need water management and treatment and often this responsibility had been left to governments.

The RATS objectives were to:

- Provide a comprehensive scientific technical and economical basis for the mining industry and governmental agencies to predict with confidence the long term management requirements for reactive tailings and waste rock; and
- Establish techniques that will enable the operation and closure of acid-generating tailings and waste rock disposal areas in a predictable, affordable timely and environmentally acceptable manner.

The program adopted the Mine Environment Neutral Drainage (MEND) name when it recognized that the program dealt more than just tailings. Waste rock was also an important element of the research program.

The Research plan was structured under 5 topic headings:

- Prediction
- Prevention and control
- Treatment
- Monitoring
- Technology transfer

The research plan was estimated to cost $12.5 mill CAD over 5 years with one third each from industry, provincial and federal government. This later was increased to over $18mill CAD using mineral development agreements between provinces and the Federal government. The agreement came following the completion of a detailed focused research plan in 1992 that had funding and projects well defined. One example was that more emphasis would be placed on sub-aqueous disposal of tailings and less on sub-marine which is not common in Canada.

The original 9-year **MEND** (Mine Environment Neutral Drainage) Program (1989-1997) and its subsequent initiative MEND2000 (1998-2000) contributed greatly to the understanding of acidic drainage. Tremendous technical progress was made in the areas of prediction and modelling, prevention and control, disposal technologies, lime treatment, passive treatment and monitoring.

Despite the progress, acidic drainage remains the most significant environmental issue facing the mining industry, governments and the public. Therefore in 2001, funding was provided to launch a renewed initiative, called MEND3 (recently renamed “MEND”), to identify Canadian national and/or regional information needs. Work continues to this day with a much reduced budget base. An integral part of MEND is technology transfer - the dissemination of information on developed technologies to the partners and the public. MAC started to fund one, then two people in 1989.

[37] Research Plan. Reactive Acid Tailings Stabilization Program (RATS). CANMET Special Publication SP88-3. (ISBN 0-662-55942-8)

Later, in 1994, CANMET (Canadian Centre for Mineral and Energy Technology)[38] underwent a major re-organization and review which did not impact MEND greatly. But this change set a course for a new direction with a strong emphasis on a 'cost recovery structure' meaning that projects in the wider organization needed to address the needs of clients more closely and projects which could not be directly funded by a client would end.

See **Section 4.4.4** on Canmet – MMSL research.

The MEND model of collaboration has been used successfully by numerous other national and international programs. Examples of MEND-based programs directed towards environmental improvements include the Aquatic Effects Technology Evaluation (AETE–Canada) Program, the Toxicological Investigations of Mining Effluents (TIME-Canada) Network, the National Orphaned and Abandoned Mines Initiative (NOAMI-Canada) and the Acid Drainage Technology Initiative (ADTI-Coal and ADTI-Metal – USA).

The MEND Organizing Committee has been selected to host the **9th ICARD** (International Conference on Acid Rock Drainage) in Ottawa in the spring of 2012. Held every 3 years this forum is the most important international conference for leading-edge acidic drainage research and problem solving.

MEND and NOAMI provide valuable case studies of how leading practice national initiatives can address collective challenges across provincial boundaries by engaging all key groups and expertise through multi-stakeholder advisory committees.

INDIAN AND NORTHERN AFFAIRS (INAC), CANADA

This section describes INAC's perspective from a meeting with Mike Nahir, on the AG report (2002) and abandoned mine management on federal land. INAC manage most of the federal land north of 60 degrees latitude, namely; North West Territories, Yukon and Nunavut.

The Contaminated sites management program (CSMP) is a national initiative to identify and document environmental problems on over 800 inhabited reserves. This effort began in June 1992 under the Environmental Issues Inventory and Remediation Plan (EIIRP) until 2003 when the CSMP was initiated to continue the assessment and remediation of contaminated sites on reserve lands. The policy for this program can be viewed on their website[39].

The key stakeholders are INAC (as a trustee of Crown lands and assets on reserves with responsibility for administering the *Indian Act*) and First Nations (as occupants of the reserves and as individual certificate of possession holders).

IN 2002, $555 million was estimated by INAC for clean up of contaminated sites. These sites include both abandoned mines and other contaminated sites such as ex-military bases. In the year in which the AG report was undertaken (2002) $26 mill was spent by INAC to manage contaminated water. The AG stated that 'this band-aid approach does little to solve problems in the long term'.

[38] In 1994, the two research arms of CANMET, Energy and Minerals were split into different sectors. then 'CANMET' was only retained to provide continuity
[39] http://www.ainc-inac.gc.ca/enr/cts/csmp-eng.asp

Four abandoned mines were visited as part of the national audit and are summarized in **Table 1** (Exhibit 3.3, Auditor General's report [36]).

Table 1: Four abandoned mines managed by INAC

	Colomac Mine	**Giant Mine**	**Faro Mine**	**Mount Nansen mine**
Department's cost estimate for clean up	$70 mill	$52.8 million to $399.9 million, depending on option selected	At least $200 million	$6.3 million
Amount of financial security collected from owner	$1.5 mill	$400,000 from Royal Oak Mines and $7 million from Miramar	$14 million	$445,000
Main environmental problem	Mine waste area is filling up with water that is contaminated with ammonia, cyanide and metals. There is potential for a dam failure.	237,000 tons of arsenic trioxide dust are stored in underground chambers. Water coming in contact with the chambers is being contaminated with arsenic and is pumped to surface and treated and released	Water is contaminated with acid and metals (zinc) and requires continuous treatment. There is potential for a dam failure.	Water is contaminated with arsenic, cyanide and metals and requires continuous treatment. There is potential for dam failure.

Performance reporting provides information on both environmental and socio economic performance[40]. The latter includes employment and training figures including aboriginal people. These reports also describe all consultation which has been carried out. The performance report is able to define all sites and their status. With 1828 sites in the CSP inventory, 1020 have been assessed and require no action, while 808 still require action. Of the latter requiring action 20 have contingent liabilities and 788 have been assessed and are suspected of having contaminated sites or physical hazards. Of these 348 have been assessed and 440 remain to be assessed.

Future directions for the program include:

- Development of an integrated risk management (IRM) program for the CSP;
- Refining the socio-economic indicators and reporting on performance;
- Conducting a training needs analysis to obtain a better understanding of the training needs of Project Managers and developing specific training initiatives to meet these needs; and
- Continued management system implementation.

[40] Northern Affairs Organisation contaminated sites program, Performance report, 2006-2007

In **summary**; The Federal government auditor general's report was a critical turning point in the management of abandoned mines of Federal responsibility. Not only did full accounting of liability have to take place, but also programs were put in place to ensure that liability was reduced in a reasonable time frame. This enabled detailed information gathering and closure /rehabilitation plans to be developed by INAC.

INAC manages the sites and associated projects using external expertise/ consultancy teams to gather information and develop plans. Risk assessment and prioritisation of sites and individual site risks, are integral to planning processes. In addition to this process INAC also complete risk assessments related to delaying of commencement of rehabilitation by the government, so that it is clear what the impacts are, due to such delays. This type of risk assessment was initiated for the larger complex site rehabilitation plans when INAC found that they had to gain approval via the same government regulatory processes as a new mining project. It was recognised that this approvals process would delay commencement by more than 1 year. INAC use expert panels to review plans and to also provide input to risk assessments. This process works well by providing an efficient and independent decision making process before INAC embarks on rehabilitation projects which will require hundreds of millions of public funds (ie Faro and Giant mines).

CANADIAN NUCLEAR SAFETY COMMISSION (CNSC)

A meeting with Jean LeClair from the uranium regulator, CNSC provided some additional information on Canadian uranium legacy sites. All nuclear regulatory aspects are managed at a Federal level and most mines lie within one province, Saskatchewan. Key personnel are located in Ottawa and Saskatoon. Their organizational chart indicates that management of former uranium minesites fall under the 'inactive' mine and mill category (on the right hand side of the organizational chart) and are managed by the Province or former operators.

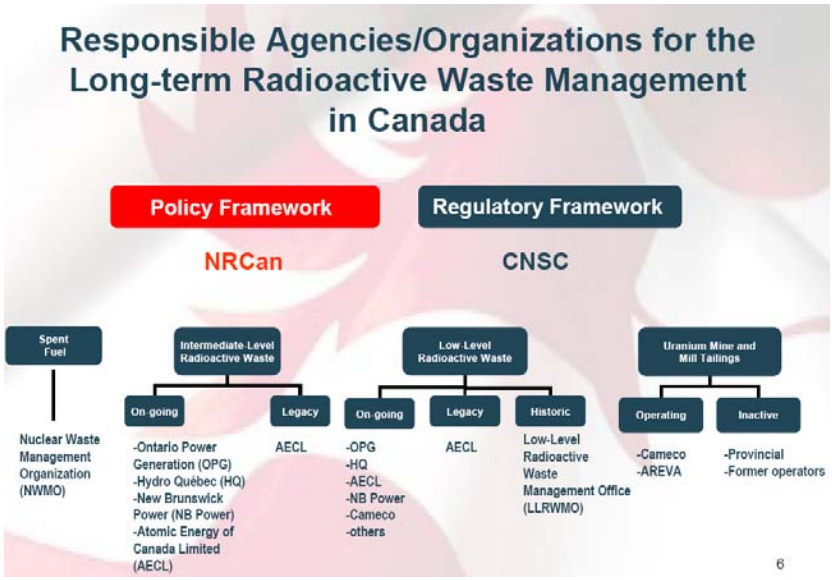


Image courtesy of J LeClair, CNSC

A complete inventory of waste rock and mill tailings at sites that are not longer operational is recorded by CNSC[41]. The site name, company or government which is now responsible for it, the storage methods and actual tonnages of materials area all

[41] Canadian National report for the joint convention on safety of spent fuel management and on the safety of radioactive waste management, 3rd report, October 2008, 200pp (p31, p165)

included. Also included is a brief history of these sites and a description of how the sites are managed and what rehabilitation has been undertaken. Funding has been committed for remediation of Saskatchewan legacy minesites. This involves a memorandum of understanding to ensure 50-50 cost sharing. The environmental assessment of cleanup projects is underway.

ENGLISH PARTNERSHIPS

As part of the Cornwall leg of my program I learned about 'English Partnerships' (EP) which was a national regeneration agency for England to revitalise communities decimated by closure of coal mines[42]. Later EP joined with the Housing Corporation (2008) and became the Homes and Communities Agency (HCA) which is a quango 'hosted' by a government department ie Communities and Local Government which reports into the Housing Minister[43]. This group purchased the land to enable the **Heartlands** project remediation and the development of housing and recreation to occur.

UMTRA, USA

Uranium production from the 1940's to the 1970's resulted in large quantities of radiologically contaminated waste at 24 legacy sites and 16 active sites in the USA[44]. Radium-226, Radium 228 and radon were the principle concerns. The **Uranium Mill Tailings Remedial Action** (UMTRA) program was developed to rehabilitate these sites.

Laws were introduced to provide the framework for the program and to support subsequent funding for implementation. In 1978 Public Law-95-604 was enacted by the US Congress and the law identified two types of sites;

- Title I – abandoned (22-24)
- Title II - active (16)
- National law
- Identified responsible parties
- EPA establishes remediation standards
- NRC provides regulatory oversight for the remediation
- DOE responsible for remediation
- Identified 22 specific legacy sites (abandoned uranium mills)
- Established 7 year completion deadline (amended twice to 20 years total)
- Required Federal government to pay 90%, states to pay 10%

The National Law required;

- DOE (Department of Environment) to develop an Environmental Impact Statement for each site;
- a design life of 1000 years and in no case less than 200 years;
- Initially addressed only surface contamination later (1988) amended to include groundwater with no time limit on remediation;
- Required zero maintenance.

[42] http://www.englishpartnerships.co.uk/coalfields.htm
[43] www.homesandcommunities.co.uk see coalfields and land stabilisation
[44] Uranium Mill Tailings Remedial Action (UMTRA) ppt by Russel Edge, Waste Safety Specialist,Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety, IAEA

Title 1 project status:

- 22 sites completed
- 5,335 vicinity properties cleaned up
- 18 disposal cells licensed by NRC
- 33.5 million m3 of tailings encapsulated
- 35.8 million km of waste and cover material transported without a fatality
- Injury rate 85% below national average of construction industry
- 1.8 billion USD spent in the process and growing

Lessons learned:

- Technical Approach Document and Standard Format and Content Guide invaluable in terms of working with the regulator;
- Good Planning essential;
- Good Communication essential;
- Master Schedule with critical path milestones;
- Early and consistent involvement with the public crucial for success;
- Early and consistent involvement with the regulator crucial for success;
- Usually volumes of contaminated material are greater than initially thought potentially resulting in design impacts;
- There will be maintenance required;
- Performance of disposal cells change over time;
- Site specific risk based approach the most cost effective; and
- "Design to accommodate mother nature rather than fight her".

GOVERNMENT OWNED COMPANIES MANAGING MAJOR PROJECTS IN FORMER EAST GERMANY

Two case studies from brown coal and uranium mining regions are described below.

Abandoned brown coal mines

IBA Fürst-Pückler-Land[45] is the 10 year landscape architecture/town planning project showcased in its 9th year, at a conference in Germany at Grossräschen by **IBA-SEE** "Opportunity: post-mining landscapes", 15-17 Sep 2009. Both English and German (see=lake) meanings were intended by conference planners to **show** the world this new regional landscape dominated by **lakes.** The region is about 100km by 60km in size and is close to the Polish border (**see Figure 1**) and located between Dresden and Berlin.

[45] Prince Pückler Country

Figure 1: Lusatian lake region following brown coal mining eastern Germany

Image courtesy of IBA Fürst-Pückler-Land, Map by Mesh design

Following reunification of East and West Germany in 1990 many government (German-Russian) owned mines were deemed uneconomic in the new economy, due to the need to remunerate employees with comparable wages and conditions to those in the west. This lead to mass redundancies within the workforce and hundreds of thousands of people left these areas. There was also a need to raise the level of environmental protection to that acceptable to the new nation so a major rehabilitation project commenced.

Two Federal government owned and funded entities were formed, **LMBV**[46] and **IBA SEE.** LMBV's role was initially to selling off government owned mining companies and then developed to manage key threats and impacts from historic mines including;

- Physical and geochemical stability of pit walls and overburden dumps;
- Ground and surface water monitoring and management;
- Planned filling of voids;
- Water treatment; and
- Engineering design of lakes, canals, weirs and other structures.

This involved preparation of operational plans for decommissioning, collaboration for rededication of land areas, project execution and contract management as well as monitoring of project work to eventually remove the rehabilitated facilities from government ownership and responsibility.

Concurrent and working closely with LMBV is **IBA** who are managing a 10 year program initiated to focus on the built environment, landscape design and post-mining land use 'to intensify the structural transformation already underway in the Lausitz region'[47].They are also marketing this region to attract tourists and other

[46] Lausitz and central German mining administration company
[47] IBA-Halbzeitdokumentation, 2000-2010 (2005) (half way review document)

visitors to the region. They are neither a government nor regional authority but a fixed duration limited company (GmbH).

At commencement of rehabilitation a range of scenarios were considered, one which involved destroying all evidence of past mining in order to make the area safe and fully rehabilitate it. Another opposing view included doing very little except turning the dewatering pumps off which had kept the pits dry, thereby allowing the voids to fill with water.

While the symbolism of this fascinated many artistic perspectives it was acknowledged that there were significant safety issues which needed to be addressed. The chosen option was sustainable redevelopment as the damage which had occurred to the environment had been too extreme for 'self-healing powers of nature to cope with'[49]. Because of the loss of identity of the region if all trace of mining were removed, it was decided to keep some of the major features such as the F60 mining site at Lichterfelder shown in the **photo**. This is a conveyor bridge which previously cut and transferred overburden, (mainly sand) from in front of mining to behind mining, thereby partially backfilling the void. In the valley underneath the F60 the coal was removed. The F60 moved on rail tracks across the mine pit and is a unique piece of equipment in this area of Germany due to the flat coal strata. When mining stopped this massive piece of equipment was left and the landscape rehabilitated around it, and now offers guided tours and alight and sound show at night.

The Power station in Plessa, the Marga miners colony in Brieske and the Bio-towers in Lauchhammer are other examples.

Five years into the project (2005) IBA were managing 24 projects classified by theme and area into nine landscape units or 'islands'. Every landscape 'island' was managed by a board which had the function of providing coordination between all interests[48].

The IBA has neither planning rights nor any powers of formal authority, the only means it has are those of communication. The IBA is able to propose and initiate projects and bring together suitable decision-makers and bringing in design expertise. They provide opportunities for unconventional ideas to be developed.

The three day conference IBA-SEE 'Opportunity: Post-mining landscapes' was organized to showcase this project to the world. The tenth and final year of the project is 2010 however there are so many other events planned as part of its conclusion, the conference had to be held 12 months prior. Conference organizers sought feedback as well as endorsement of this IBA project.

Day 1 focused on a trip around the world where we learned about abandoned mine rehabilitation and post-mining land use from other nations including South Africa,

[48] http://www.iba-see.de/en/erleben/projekte.html for details on projects

China, France, England, Portugal, USA, Chile, Sweden. Some of the case studies from these countries have been referred to elsewhere in the report.

We were also introduced to the **ten principles** which were proposed 'for the treatment of post-mining landscapes' as a focal point for the conference. They are:

1. Setting an example
2. Using resources
3. Fostering identity
4. Broadening the planning horizon
5. Shaping the process
6. Allowing for creativity and innovation
7. Generating pictures
8. Ensuring transparency
9. Building the organizational structure
10. Taking responsibility

A large outdoor magnetic board with 10 headings was provided so comments could be posted during the conference.

During the morning of **Day 2** concurrent sessions under different themes drew on further case studies and we were asked to draw on the diverse experiences gathered to discuss the applicability of these principles to other projects. Themes were: A Strategies and Instruments, B Change of Identity and C Land use instruments.

These principles provided an insight into the planning of the IBA-SEE project and provide an excellent model for other projects which want to add value to a rehabilitation project by developing the socio-economic potential of a previously mined region.

Not included in this list however, are those principles which were applied by LMBV to ensure safety and environmental liabilities were addressed, via evaluation and quantification of risks. This was then used to address high risk aspects such as stabilization of pit walls to minimize collapse during filling as the groundwater table returned to its natural level. They also continue to be involved in AMD water treatment by pumping lime into voids in the process of filling. In-pit waste dumps contain sulfide minerals which are weathering and turning waters acid during the filling stage. They will continue to manage the water until neutral and stable conditions are verified.

The first phase of the IBA project focused on retaining key elements which might have otherwise been destroyed by rehabilitation and the second phase has involved the introduction of new elements eg. The lookout tower 'the rusty nail' provides views of lakes and canals and one of several iconic symbols for the project. A key challenge appears to have been to provide sufficient connection to the past whilst removing the hazardous components and changing the landscape. It would have been valuable to learn about some of the areas of conflict which were overcome, such as relocation of any residential areas and/or businesses and impacts/ benefits from new businesses (eg Seehotel near the conference venue).

The conference aimed to communicate to the world the vision and progress of the IBA project. It also engaged international perspectives on, and endorsement for, the project. Some participants noted that there did not appear to be representation from the local community at this forum. This could have provided the additional local dimension on how communities were involved in the decision making processes for this new landscape.

This fixed term project provides valuable insights into what can be achieved with a clearly defined program but it is not clear what will happen when that pool of expertise is withdrawn at the end of the project. How will the transition be managed?

From a technical perspective LMBV provided input during the landscape tour on how water and safety aspects were managed;

- The pit walls and 'fill' where waste dumps lie inside the perimeter of the pit, had to have 'invisible dams' built. This involved a pile driving type rig penetrating to the base of the pit to the side of the final void and vibrating the fill (largely sand and finer materials) until it reached optimal consolidation. A band of about 150 m is treated in this way around the margins of the final voids in fill to ensure geotechnical stability of these features called invisible dams;
- Voids were at different stages of filling and most contained acid water caused by weathering of sulfide minerals in waste dumps and voids. These materials were left exposed when mining halted. There was general lack of aquatic life in new lakes due to AMD;
- The filling of lakes has been accelerated where possible using water from the two main rivers, the Niesse and the Spree but LMBV are restricted on the volumes taken to ensure sufficient environmental flows are maintained in those major rivers;
- Water treatment is undertaken by pumping a lime slurry into the bottom of the lakes;
- There would be an ongoing requirement to treat water until long term water quality uncertainties were resolved;
- With fishing and boating and future floating houses to be constructed on the lakes the success of this project is largely reliant upon good water quality. There are historic water filled pits in the area which are not acid so LMBV felt confident there was evidence that they could achieve the same here. Once covered by water the weathering of sulfide minerals will slow, however ongoing monitoring and management will be required until geochemical stability is achieved;
- Areas where inner dumps were only just below the surface posed navigational challenges, however It was not anticipated that this would continue to be a problem once the lakes were fully filled;
- New channels are still being built, connecting the lakes;
- Canal-lake tunnels would be built to go under roads and railways and these have been designed to accommodate bikes and pedestrians;
- Modeling had been carried out and monitoring was providing data so that limnology of the lakes and seasonal changes/mixing were understood;
- Uncertainty remained as to the point in time when water quality would be stable and proven to be so, to the satisfaction of local authorities so they would be confident to take responsibility for the lakes in the future. Nevertheless it was clear that LMBV (and funding) would continue while there are impacts to be managed;

Photos show: 'Rusty nail' lookout, canal weir between two lakes, iron staining due to AMD on foreshore of partially filled mine void.

Following the afternoon tour of the lakes and attractions which took about seven hours, Day 2 concluded with a performance of Baroque opera music accompanied by dance. These performances portrayed mining and the evolving new landscape.

Day 3 included a summing up session based on the outcomes of concurrent sessions from Day 2 and notes contributed by participants on the 10 principles. The conference concluded with an inspiring presentation by **Dr. Ernst Ulrich von Weizsäcker**, International Panel on Sustainable Resource Management on sustainable development in 2050. An artist's impression of the final landscape in the vicinity of the conference venue is shown.

Image courtesy of IBA Fürst-Pückler-Land
By Profifoto Kliche

Abandoned uranium mines

Wismut extracted uranium ore from the region of Saxony and Thuringia, Germany (**Figure 2**). It was a synonym for the Soviet-East Germany Uranium mining industry and was the world's 3rd largest producer until 1990. About 216, 000 tonnes of uranium were mined between 1946 and 1990.

In 1990, liabilities comprised 37 km^2 area, about 320 million m^3 waste rock, 178 million m^3 of uranium mill tailings, one open pit and 5 large underground mines. Since 1991 Wismut GmbH has become a federal government-owned company whose principal business is the decommissioning, cleanup, and rehabilitation of these mining and processing sites in possibly the world's largest mine closure program[49]. About 1500 people were employed for this program. By 2008 more than 98% of underground workings were remediated and 70% of surface remediation completed. The physical remediation works are expected to be largely completed by 2015 and following this, water treatment, environmental monitoring and maintenance will become the prime focus in a scaled back operation.

[49] Paul, M, Mann, S and Jakubick, A, Environmental clean-up of the East German uranium mining legacy: The WISMUT remediation program, presented at 8th ICARD June 2009, Sweden

Figure 2: Location of Wismut rehabilitation areas south-west of Dresden

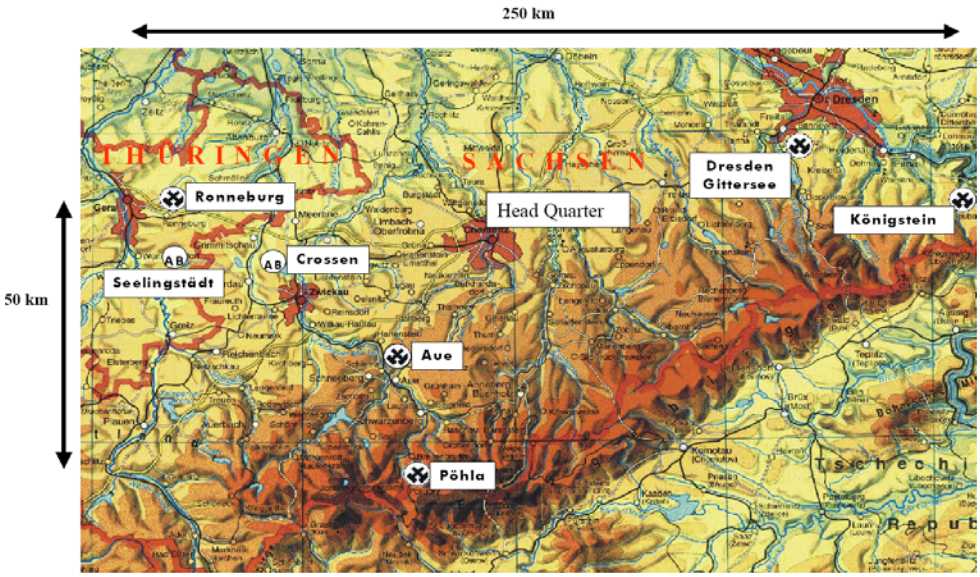


Image courtesy of Dr M Paul, Wismut

Wismut were able to provide insights, from about 20 year's experience, on the following;

- project objectives and how they were evaluated during and after works were completed;
- funding, political and stakeholder support;
- planning processes for this large and complex project comprising open cut, underground and block leaching mining methods, with stability and contamination issues (soil, water, air);
- new technologies and methods;
- prioritisation and 'stages' of work;
- multi-disciplinary teams;
- post-mining land uses; and
- long term management of residual issues.

Site inspections included:

- Crossen, Helmsdorf/ Dänkritz 1, Seelingstädt , Culmitzsch, Trünzig, Ronneburg, BUGA area and exhibition 'Objekt 90', Gera with Ulf Barnekow, Head of Department for Mine Remediation;
- Hartenstein (Aue branch), information centre, Aue/Schlema-Alberoda with Dr Ulf Jenk, Coordinator hydrology, Königstein and Mario Paeszler field operator, air monitoring radiation protection at Aue
- Presentations on organization of the WISMUT-Monitoring and environmental data base and Implementation of the ICRP-principle of radiation protection and IAEA Standards.

And presentations by/meetings with:

- Dr Michael Paul, Division Head, development and monitoring,
- Axel Hiller, Head of Geological Archives,
- Jens Regner, Senior Expert Radiation Measurement/EIA, Dept of Monitoring /Radiation Protection/Hydrology, and
- Elke Kreyszig, Head of Environmental Monitoring, and Jana Goetze (monitoring).

The primary objectives of Wismut's environmental remediation program are to;

- address radiological and water quality health risks associated with the close proximity of residual workings to urban areas;
- mitigate existing environmental damage and prevent future hazard; and
- protect the health and safety of employees involved in the remediation program.

Planning required a significant investigation program. Each mining area was different and each of the key processes requiring attention was slightly different. Acid and metalliferous mine drainage (AMD) issues are also important to varying degrees. There were also reputational issues to overcome due to the Wismut name being associated with negative impacts and secrecy within its uranium mining and milling history. Conceptual plans were prepared for each site and the focus was on elimination of the source of the risk by either total cleanup and relocation. Wastes were covered to reduce radiation exposure or release of contaminants and discharge of water was controlled by water treatment.

To assist with planning Wismut used knowledge from overseas from the United States' Uranium Mill Tailings Remediation Action (**UMTRA**) program. This professional forum linking the two programs became **UMREG** (Uranium Mining Remediation Exchange Group) and this group has meanwhile expanded to incorporate other nations including Australia (see IAEA **Section 4.5.1**). Wisutec, a daughter company of Wismut, was established with the aim of transferring the knowledge gained, to a broader application.

Additional abandoned mines in Saxony - The Wismut remediation program (defined by legislation) did not include mines which were abandoned in the 1950's and 1960's and hence, were not operating until 1990. These abandoned mines, comprising smaller areas, pose similar challenges however are managed in a different program with funding jointly provided by the Federal Government and the State of Saxony (50:50). About half of this work is carried out by Wismut GmbH, using valuable expertise, knowledge and databases of Wismut and half by the private sector. The separate funding has been allocated to this work; €78million 2003-2012 (10 years) with a maximum of €10mill/year.

Photos show tailings rehabilitation areas (top) and visitor's centre 'Objekt 90', display within the visitor's centre showing a backfilled Litchenberg pit and BUGA horticultural exhibition site, Ronneburg (bottom L to R).






Observations

SUCCESSFUL ASPECTS

- Reunification provided strong and decisive political motivation to address the legacy issues of uranium mining in south-eastern Germany.
- There was also a focus on retaining valuable skills to prevent even more unemployment than was occurring dramatically at this time.
- Funds were made available immediately so work was able to commence (in 1990) on urgent remediation concurrent with development of detailed plans for overall program.
- Urgent works included: Fencing and other control of access to tailings and areas which needed to be restricted for health and safety reasons, addressing dust issues with interim covering of dry tailings beaches, and relocation of waste materials which represented 'hot spots' i.e. high radiological exposure risks.
- The second phase involved design planning and alternatives to look for the best possible option in terms of cost effectiveness and reaching remediation targets.
- Cost estimation of total works of $13 billion DM in 1991, ensured substantial funds were set aside. This was a fairly accurate estimate (but not the duration of the project) when considering the context;
    - o political transformation,
    - o change in focus of the company from mining to rehabilitation; and
    - o limited ability to foresee future standards and requirements for the methods and technology of remediation to be applied.
- A strong positive aspect of this project has been the continuity of information from former Russian-German management to the present. This is evidenced not only in the retention of key personnel but also the careful management of archives. Wismut are a valuable resource for this information for many other regional uses eg. external organisations seeking to access geological records from numerous deep drill holes for evaluation of geothermal energy.
- Availability of long term monitoring data.
- Improvements have been made to data quality collected since 1990. The new system for data collection, quality control and review is impressive from many perspectives. It has the ability to collect and manage a huge volume of data from;
    - o a variety of sources; and
    - o the full range of monitoring parameters.

  Data are available in an easily accessible electronic format. Wismut's monitoring program demonstrates:
    - o Significant effort which is not always visible to the outsider to develop and maintain high quality data sets;
    - o Protocols for sampling to ensure consistency;
    - o Protocols for collection of new data to ensure due consideration to the purpose and expectations; and
    - o Evidence of ongoing continual improvement in terms of database management.
- With Wismut's major shift in focus from a mining company with a negative reputation, toward a remediation company intent on building a good reputation, the community has responded accordingly. There is greater trust due to more open comunication and design and implementation of 'best practice' i.e. doing the job completely, no half-measures.
- Employee health programs were pre-existing before1990 and these continued with separate funding for this aspect.
- The boundaries of the project were clearly defined from the start, later when other areas were identified they were managed through the State 'Abandoned mine program', managed by Wismut under separate funding.

- Good continuity of key people during most of the large and complex work, i.e. specialists in mining and mining related areas were retained as there were not many alternative jobs in these fields at the time. This helped to maintain a stable workforce at professional and project management and operator level.
- Key processes determine focus of remediation effort ie. Aue – radon gas management, Königstein – *insitu* block leaching and groundwater contamination, Seelingstadt - geotechnical management of tailings remediation – dewatering to speed up consolidation and ensure successful capping and surface water management.
- Environmental impact assessments were undertaken for each individual project to address individual permitting processes (8000 projects).
- Radiological dose objective was < 1mS/yr for the nearby population during and after remediation, and to ensure workforce limits. Those were met throughout.
- At Ronneburg separate object plans were integrated to make it work due to the interconnections ie. flooding of underground workings and moving waste dumps to the open pit.
- The general approach to radiation protection optimisation was that the maximum amount of waste rock was relocated to fill the hole then two smaller dumps were left in place.
- Acceptable post-mining land use will not include habitation but allows recreational use and forestry with the latter being the most common use.
- Forestry provides a self-sustaining and low cost option in the long term, compared to grassland which needs mowing or will develop into forest anyway.
- Wismut have undertaken grazing trials with sheep varieties. It is not possible to find a zero cost option as they have to pay shepherds.
- Wismut owns this land and will end up managing this land.
- The golf course built on a rehabilitated mine landform at Schlema was sold to the golf club however if it goes bankrupt and they can't carry out the monitoring it will fall back to Wismut or a subsequent manager. This is a special case land use.

CHALLENGES

- The duration of the whole remediation project was under-estimated and this has been part of an ongoing process of negotiation. With high fixed costs time becomes a critical aspect.
- Long term management needs for residual impacts were not well known in the beginning. They include; water, air (extraction of radon from underground workings) and maintenance of remediated areas, once completed. Also monitoring of all aspects which is important to provide evidence of performance and that standards (international radiological standards) are continuing to be met.
- Seelingstadt and Ronneburg are in the same catchment – water treatment plants (WTP) at both sites must be operated in an integrated manner to control sulfphate and hardness loads. In summer due to low river flows, the Seelingstadt WTP is to be turned off temporarily. Consideration is being given to purchase water from reservoirs to stabilise the base flow to maintain higher water levels and dilution of salts in summer as this may be more efficient than additional water treatment.
- Fluctuating loads in water requiring treatment throughout the project. Volumes will be lower in 2012. Treatment methods and volume influence sludge volumes for disposal and overall costs. The storage and delayed release of treated water to maximise dilution, is another consideration within the optimisation process.
- Regulatory requirements - at one site runoff from a rehabilitated tailings dam area flowed into another State. This complicated the project due to the subjective influences of inexperienced regulators. In some cases approval of a technique in one state but not the other.

- Water treatment duration/costs perhaps less clear when early estimates were done as knowledge has evolved with the project.
- Rehabilitation often required removal of established forest to remove old dumps or flatten slopes and construct covers. The project had to undertake compensational reafforestation with stringent time boundaries in which to do this;
- There is an aim is to create mixed species forestry with no intensive intervention on rehabilitated waste rock dumps. It may be possible to use areas for renewable production of energy, using plantation forestry. It is difficult to find an investor due to the low quality of soils and low yields. Sites are remote, small and steep.
- The nature of forestry operations needs to be defined to minimise negative impacts on the performance of covers. Selective logging has not been assessed until recently.
- Root penetration can lead to a loss of cover performance. In the case of water this will be compensated by the higher evapotranspiration of the forest.
- Contracts with forestry enterprises for maintenance and care of these young forests to guarantee a minimum density for 5 years to make sure 80% maintained or have to replant (based on surveys) to maintain young forest If too dense, then they have to thin trees. There is also a need to fence planted areas to prevent grazing of young trees by grazing animals, e.g. one deer can graze all of the oaks in an area.
- By the middle of the next decade when all rehabilitation works are finalised Wismut will transition to the monitoring phase.
- Culmitzsch tailings stabilisation will be the last huge earthworks project due to delays in permitting, standby of WTP and a relative shortage in funding. It is expected to finish around 2020.
- Completing works in a declining budget environment is difficult;
- The political will to finish is very strong but may not be aligned with the work which remains.
- The importance of stakeholder involvement was underestimated at the very beginning in terms of planning and post mine land use.
- German mining laws require community consultation but implementation can vary from superficial to in-depth.
- Early wild days of the project involved tension between ‘old Wismut’ and new. Old Wismut was secretive, arrogant, formerly Russian-dominated, all power was with the uranium producer, and miners were privileged people earning high incomes compared with general public.
- After 1990/1 with many of the same people, the public wanted to see new people to overcome the old arrogant behaviour. ‘We have funding, we are running this program’ from upper management. Some sites were better than others depending upon attitude and relationships with mayor – some ex-Wismut who did not have a good relationship with the company, creating conflict and an environment of mistrust. This delayed work and limited Wismut’s ability to get clever solutions from community.
- ‘Open houses’ are held annually at all sites, where Wismut personnel give presentations to communities explaining their work and what is planned. More recently it has been learned that non-technical issues are more crucial for consultation as most technical solutions exist. To make these work, however, there is a need to come to an agreement with many stakeholders: community, mayor and NGOs.
- In Ronneburg there is a NGO protestant church (anti -Wismut/uranium ie. small ‘green’ group who were difficult). If they had been taken seriously early there would have been less problems. Now this group is engaged earlier and this provides better outcomes. Activists can call Dr Paul when they have concerns,

where they have a very open dialogue. Improved accessibility has lead to improvements overall.

- There is a perception within Wismut that as a government owned company they were regulated more stringently than if not government but private industry;
- The desire to devolve responsibilities from federal to state causes conflicts which also delay progress;
- Development of major rehabilitation task solutions took almost 10 years partly due to more difficult permitting processes than were predicted initially (ie to apply different methods of rehabilitation for wet and dry tailings). This has contributed to the longer duration of the overall project. Early on it was easy to get started and get permits, then from the mid 1990's approvals processes became more complicated and slower.
- Post-mining land uses include; golf course, spa area, parks, recreation and forests. Forestry will require further investigations regarding disturbance of covers and the impact on performance of those covers.
- Hard to hold a good team together in a declining budget environment
- Evidence of strong leadership now and in the recent past, and a high level of teamwork and that this has been a significant component of the success of this project
- The world needs leading practice examples to learn from. The Wismut project is one and this organisation has the capacity to share this knowledge via conferences and other technical forums as well as hosting visits from technical personnel from other countries. The value of this aspect is probably underestimated. In a declining budget it may become harder for the sharing of this knowledge.
- Dr Paul and his team are managing a huge and complex project which addresses the environmental and human health and safety objectives, whilst also incorporating a range of post-mining land uses. This multi-disciplinary approach has developed robust solutions by ensuring rigorous site evaluations and impact assessments focussed on key processes.

Photos (clockwise from top left); one of the few remaining unrehabilitated sites, or 'objects', radon extraction point, drainage works on waste dumps, golf course on rehabilitated dump, treated water released to river and WTP sludge disposal.






Residual issues to be managed

Ongoing issues which require management after completion of the rehabilitation works include, radon, water and sludges from water treatment.

The political pressure exists to 'complete' the program and while the major remediation works are on track to achieve this, there are some grey areas regarding the ongoing need to manage and treat water, monitor the flooding of underground workings and remediation of groundwater systems as well as to manage radon gas extraction at Aue.

With the need to maintain water treatment there is also the need to dispose of water treatment sludges. Current practice involves immobilising contaminants in cement blocks which are buried in well designed and constructed impoundments. Monitoring must ensure objectives of remediation continue to be maintained, not only to verify the success of methods used but to provide further public confidence in the program. Currently Wismut is in a phase where every year's budget is less than the last. Several large tailings facilities are still undergoing dewatering and are having covers constructed and these works comprise the major cost and project management tasks still being completed.

Wismut - successful post-mining land uses

The Rehabilitation of former uranium mining areas of east Germany by Wismut have enabled communities to remain in this region in close proximity to past workings by successfully rehabilitating and making safe this once dangerous landscape.

Many post-mining land uses have been incorporated into the project namely; a golf course, forest, grazing land and wetland areas. Also the landmark project of Schlema which has been successfully restored its former glory as a spa town. Another landmark project is at Ronneburg where the rehabilitated mine landscape including visitors centre and event venue, hosted the national horticultural exhibition in 2007 which attracted nearly 1.5 million people.

4.4.2 NON-GOVERNMENT

The **National Trust** is one of the UK's biggest land-owners, and is a membership organisation dedicated to conserving the UK's unique natural and built heritage. It has about 3.5 million members and is a powerful national voice in related issues (see also **Section 4.1.2**). The role of the NGO needs to be recognized at this level of influence. The National Trust in UK may have alliances with Australia's National Trust. The skills and knowledge of the Australian National Trust may need to be tapped into to support beneficial post-mining land use in Australia and as such would be a stakeholder in abandoned mine rehabilitation where there are heritage values to be managed.

4.4.3 MINING INDUSTRY

MINING ASSOCIATION OF CANADA (MAC)

This section briefly describes the role of MAC in NOAMI and MEND. Canada is the only country in the world to address, comprehensively, and through a **multi-stakeholder process**, the mining industry's legacy of orphaned and abandoned mines. The leadership shown by The Mining Association of Canada (MAC) helped to develop NOAMI eight years ago and their ongoing support helps to sustain the

initiative both with funding from industry as well as more broad based support from each of the provincial governments[50].

NOAMI has been successful because of its multi-stakeholder nature and diverse funding sources have helped to sustain it. Funding has come from MAC, the Professional Developers and Prospectors (PDAC) and the provincial governments and some Federal funding.

The MEND program which preceded NOAMI and continues in parallel, may have also helped to provide support for the secretariat as it enables the use of existing well developed and trusted networks within Canada and overseas whilst also tapping into the highly relevant technical area of AMD.

Research partnerships are key to the environmental performance of the mining industry. MAC and its members have contributed to various research networks over the years. They have been involved with the MEND and NOAMI programs over the years. Currently , Elizabeth Gardiner is the Chair of the MEND Steering Committee and has been an active members of the NOAMI Advisory Committee since its inception in 2001.

MAC's other initiatives which support sustainability

The "Toward Sustainable Mining" (TSM[51]) initiative was launched in 2004 and was made a condition of membership by the MAC Board of Directors. Since that time MAC members have;

- Reported against performance indicators for tailings management, energy management, external outreach and crisis management planning;
- Developed and implemented an external verification system for TSM performance;
- Established and worked with the 14-member Community of Interest Advisory Panel; and
- Developed policy frameworks for aboriginal relations and biodiversity.

Performance indicators are based on 5 levels from Level 1 (no systems in place; activities tend to be reactive; procedures may exist but are no integrated into policies and management systems, through to Level 5 (excellence and leadership where there is integration into management decision and business functions). The continuity of key people at MAC and NOAMI has also contributed to its success. The purpose and focus has remained a constant.

4.4.4 RESEARCH

NRCAN – CANMET- MMSL

NOAMI Secretariat, described in the previous section, is located within the CANMET-Mining and Mineral Sciences Laboratories (MMSL) of NRCan, so there are many opportunities to work together.

Key people at CANMET-MMSL (bolded are those I met with) include: Director General Louise Laverdure (Acting); Director Green Mining Research, Janice Zinck (Acting); Footprint Reduction (Tesfaye Negeri), Mine Waste Management (Bryan Tisch (Acting); Ecosystem Risk Management, Philippa Huntsma-Mapila (Acting);

[50] From a meeting with Elizabeth Gardiner, MAC
[51] http://www.mining.ca/www/Towards_Sustaining_Mining/index.php

Alain Dubreuil (Life Cycle), Mine Closure and Rehabilitation, David Koren; Special Projects,Gilles Tremblay and laboratory services.

There are likely to be parallels, and possibly already collaboration between this group and Australia's CSIRO and SMI as national research bodies working in the mining sector on sustainability issues. A sample of projects are described below.

The work of Bryan Tisch: Green Mines, Green Energy is a multi-stakeholder initiative and one project uses organic wastes such as compost and biosolids to grow crops for biofuels, on mine rehabilitation areas (trialed at Elliot Lake). Another project is using alkaline pulp mill wastes on AMD materials to provide a cover for rehabilitation, whilst also helping to mitigate acid contamination issues. The mine waste management work of Janice Zinck is aimed at reducing environmental liabilities. This work addresses AMD tailings and waste rock management as well as work on sludges to improve their geochemical stability. The mine effluents and biotechnology program of Dave Koren involves prediction, prevention and remediation developing inhibitors for AMD and other key contaminants in mine and process waters. He is working at a molecular level to identify bacteria suitable for use in low temperature wetlands.

These and other projects form a collaborative link to MEND and NOAMI not only due to their physical proximity but also communicating and linking the more strategic directions of industry and making that knowledge readily available for abandoned mines. Technology transfer via newsletters and reports occurs with the MEND and NOAMI web sites being regularly updated with report summaries, a publication list, case studies, newsletters, workshop and conference announcements and links to other relevant initiatives.

4.4.5 CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS (NATIONAL)

Although derived from national case studies some of these observations are also applicable at a state/NT level within Australia.

Conclusions;

- Wismut project managers learned from the experience of other project managers such as UMTRA via the UMREG forum, to avoid reinvention of past mistakes. These other projects also provided a valuable starting point. Australia must be similarly able to access networks. Resourcing of rehabilitation projects needs to ensure project managers can network and learn from others.
- If the Commonwealth government devolves management of Rum Jungle rehabilitation to the NT then the key personnel there will need to be able to network with other international sources as well as tapping into valuable Australian knowledge in the Supervising Scientist Division (IAEA and UMREG).
- UMTRA provided many valuable lessons for abandoned mine planning which remain relevant to projects today and these lessons are also relevant to mine sites other than uranium.
- In Australia /States/NT we seem to undervalue the importance of continuity of site knowledge – environmental, safety, mine history, industrial archaeology, community aspects. Long delays between abandonment and site assessments to evaluate risk, and preparation of management plans has resulted in reduced access to important information sources.
- There is an Abandoned Mine Working Group in Australia reporting to the MCMPR – SCO (Standing Committee of Officials), however it is not clear what

specific outcomes will be supported by the Commonwealth Government in terms of a Strategic Framework. In the past the Commonwealth government has not wanted to get involved saying 'abandoned mines are the responsibility of States/NT' and in most cases this is true. However there is a need for a minimum standard of governance by all jurisdictions managing abandoned sites, and sharing of knowledge, if we are to tackle the problem in a sustainable manner, i.e. to address the backlog and prevent more abandoned mines. Also, all stakeholders need to be engaged to ensure all obstacles to implementation are addressed as well as opportunities for beneficial land and water uses, embraced.

- Successful projects show how barriers between jurisdictions and ownership are made invisible when working together toward a common vision.
- Robust monitoring databases must be spatially accurate, handle diverse types of data, provide protocols for collection, must ensure additional sample sites expanding collection are well planned and meet high standards of database management.
- Long term water management and maintenance aspects are often underestimated in mine rehabilitation projects.
- Timing of completion of projects can easily be delayed due to regulatory processes and in some instances it is not appropriate to have the same extent of regulation for a project aimed at cleaning up the environment rather than causing harm.
- Several examples of leading practice rehabilitation projects undertaken by governments are guided and/or constrained by regulatory processes. This is not always the case in Australia. E.g. QLD mine environmental regulation does not easily enable regulation of one department of another (previously EPA and NR&M now DERM and DEEDI).
- Regulation provides more transparency and consistency. If regulatory processes not applied, or developed for a specific project, governments could be perceived as having double standards – one for the mining industry (regulation of current mines) and one for themselves (as managers of abandoned sites).
- Where sites are significantly degraded there is a strong case for expediting rehabilitation (and not passing through normal regulatory processes which may delay projects by significant months or years). Option evaluation however, needs to engage both experts and, depending upon land uses, the community or other stakeholders.
- The National Trust UK is an active stakeholder in post-mining land use.
- Significant effort is required to maintain good data sets and this effort is not always visible from the outside (Wismut). In Australia when mines go into liquidation data can be placed in the hands of receivers (or completely lost) making it unavailable for mine rehabilitation planning. The value of historic monitoring datasets (tailings dam designs etc) is often undervalued. It follows that insufficient effort is put into archiving/accessibility of data. New data from rehab projects must also be maintained long term.
- All large projects have challenges estimating total costs when only limited information is available on a site.
- Continuing to maintain high standards of work and keeping teams together during a declining budget till the end of a project is difficult. Clearly defined objectives and time frames must help, scaling down to low level maintenance of sites.
- Uranium related legacies are small in Australia compared with other mining sectors (particularly where AMD is generated).
- The separation of uranium legacies (under Commonwealth) and others under the states is related to the political/regulatory controls over uranium mining. When managing abandoned site issues however all mining types have issues in common. We must make sure there is networking across that sector divide in

terms of abandoned mine rehabilitation to tap into that knowledge (esp. SSD, IAEA).

- Concept of sustainable redevelopment was demonstrated at IBA - we can learn from this in Australia.
- CNSC inventory of nationally managed uranium sites presented in an easy to find format accessible to the public. Supported by performance reporting in same document.
- Canada is well known for establishing multi-stakeholder initiatives to address issues of national importance. This model of cooperation among industry, various levels of government, NGOs and First Nations is now applied both nationally and internationally. MEND and NOAMI are two of many successful multi-stakeholder initiatives.
- Through these multi-stakeholder initiatives, a significant advancement in environmental performance and the understanding of sustainable development as it relates to mining and society is achieved
- The MEND model of collaboration has been used successfully by numerous other national and international programs.
- Aside from its technical successes, MEND has been described as a model way for industry, governments and NGOs to cooperate in technology development for advancing environmental management in the mining industry. Decisions are now being made based on sound science. Reasons for this include:
    - The high return on the investment targeted and achieved, in terms of knowledge gained and environmental and technical awareness of the scope of the problem and credible scientific solutions;
    - The partnership and improved mutual understanding developed between the two levels of government and the mining industry in search of solutions to a major environmental problem. MEND has also fostered working relationships with environmental groups, ensuring that they are an integral part of the process;
    - The small dedicated secretariat group that coordinated activities, managed the accounting, reporting and technology transfer, and was the “glue” which held the program together. This Secretariat is located at NRCan/CANMET in Ottawa;
    - The extensive peer review process that was both formal and informal, and resulted in enhanced credibility of the information base.

Questions;

- How are the National Trust in Australia engaged in abandoned mine projects? Are there opportunities for them to work more closely with governments?
- How many more potential ‘wow factor’ sites are there in Australia which could be developed around a unique theme, which could bolster the local economy and provide a new use?
- We don’t highlight the success stories sufficiently well when it comes to innovative post-mining land uses in Australia, would some type of sponsored award help to provide exposure to this?
- Australia is linked to the Cornish Mining World Heritage Site listing but how are we able to contribute?
    - What formal communication has there been with Australia (perhaps only with South Australia?)
    - The diaspora garden at Heartlands will include plants native to Australia – who is involved in providing advice to this project or is it simply up to the Cornish projects to address this?

    - This could provide a valuable opportunity for Kings Park (WA or similar organization) to showcase Australian flora and know how (ie. Selection of species suitable to the location).
    - A key person in a link with Cornish Mining WHS has just retired (from SA PIRSA). How will that mining heritage knowledge and enthusiasm be perpetuated?
    - How can other jurisdictions learn from this alliance?
    - Are there tourism opportunities for more Cornish visitors to South Australia since WHS listing?
    - How can Australia both support the WHS in its mission and benefit from it?
- Are there any mining heritage sites in Australia worthy of evaluation for consideration of WHS listing? What national process, organisation or forum do we have for considering this?
- Who is Australia's representative on UMREG? Is there a need for such if there are few abandoned uranium mines in Australia?
- The use of expert panels to provide independence and reduce project risks, complementing the planning processes;
- Who will maintain the long term datasets for large sites before, during and after rehabilitation important for good management?
- Do we have governments or companies focused on rehabilitation and selling off land to keep it used (or are we are more inclined to lock it up to keep people out and manage safety risks)? With increasing demand for land in Australia perhaps we need to look to post-mining landscapes for new industrial land particularly when close to existing infrastructure and facilities.

Recommendations;

1) The Australian Government and State/NT governments demonstrate their commitment to the Strategic Framework **at a high level** by facilitating an Australian abandoned mine forum in 2010.

   This forum needs to engage key stakeholders, breathe life into the framework, and ensure documentation of the implementation strategy. Clearly defined objectives are needed, as are time frames, roles and responsibilities and resources to implement the strategy. Performance reporting must be integral to the overall framework.

2) The Commonwealth, State/Northern Territory Governments and Minerals Council of Australia, establish a national abandoned mine secretariat with a multi-stakeholder advisory committee in Australia.

   The purpose of the secretariat would be to implement priorities as determined by the advisory committee such as; networking, knowledge sharing, addressing obstacles to abandoned mine rehabilitation, facilitating collaboration on sustainable solutions, identifying training needs to build capacity, gathering data to support risk management, communicating leading practices locally and overseas and developing toolkits for aspects not covered by existing leading practice guides.

3) The national abandoned mine secretariat in Australia should address long term records/data management for abandoned mines (whether or not rehabilitation has been carried out) as these records can be of significant value for assessing risks and developing management plans. It could also review the pro's and con's

of regulation of mine rehabilitation projects with a view to providing appropriate guidance to state governments to facilitate transparency without adding significantly to time or costs to implement.

4) Auditor's-General of each State/NorthernTerritory as well as the Commonwealth of Australia, to undertake audits of their programs for managing abandoned mines to assess whether these programs are adequately accounting for both;
    a) liabilities; and
    b) performance.

5) All stakeholders must recognize that to achieve successful projects barriers between jurisdictions and ownership must become invisible. This can only occur when all key stakeholders are engaged and work together toward a common vision.

6) The MCMPR endorse a Strategic Framework on Abandoned Mines in Australia and support the Abandoned Mine Working Group. There must be wider stakeholder engagement for the strategy to progress and it is hoped the key themes learned from this study program will be embedded in such a framework.

7) The Commonwealth government could run a national competition to seek innovative ideas to develop a specific abandoned mine for a new use with the aim of developing a 'wow attraction'. The details of such would need to be determined as well as award and opportunities for partnerships/collaboration.

8) Consider ways of providing more rapid initial site assessment for abandoned mines so the information gathering process start earlier, to tap into local and other knowledge before key people move away or die.

9) Ensure networking between all abandoned mine rehabilitation project managers/teams irrespective of mine type or jurisdiction (through a national network). This network should also make connections with mining companies managing dormant sites with similar challenges.

10) The Commonwealth government to produce publicly accessible biennial performance reports on uranium rehabilitation projects within Australia (such as Gunlom Land Trust and Rum Jungle), in line with the State/NT requirements for biennial reporting referred to in **Section 4.3.2**. This transparency is needed to ensure government revenue is being spent in a fully accountable and well justified manner.

4.5 INTERNATIONAL

4.5.1 GOVERNMENT

International Atomic Energy Agency (IAEA)

The IAEA is the largest organization located at the international centre in Vienna and its motto is 'atoms for peace'. The IAEA address all aspects of nuclear activity and the three "pillars"of its work are: Safety and security; non-proliferation of nuclear weapons; and. Training and education. For operational uranium mine sites the UPSAT (Uranium Production Site Appraisal Team) program has been designed to assist Member States to improve the operational and safety performance of uranium production facilities through all phases of the production cycle. In my studies I focused on abandoned uranium mine programs and how the IAEA staff plan and implement projects globally and how the IAEA interacts with Australia.

The IAEA respond to requests from Member States (nations) rather than having a strategic program planning framework with specific funding allocated to projects up front. This mechanism provides a useful comparison with other programs. The IAEA do not fund rehabilitation projects but they do provide;

- guidance on standards and regulatory matters;
- training and capacity building to Member States; and,
- technical advice and peer review through using networks and knowledge to bring together appropriate expertise.

They develop and apply safety standards via the following mechanisms;

- Publications;
- Expert missions;
- Scientific visits;
- Fellowships;
- Training;
- Conferences;
- Workshops;
- Support Services; and
- Procurements.

The extensive range of IAEA guidelines and standards are all accessible via their website.

Once a Member State seeks the assistance of experts from the IAEA, a mission is planned. A team leader is appointed (or may have been the primary contact from the Member State) and the selection of team members from decommissioning, waste management and safety sections and/or external consultants is negotiated, reflecting the needs of, and funding from, the member State(s). The experts may be in-house or external consultants or a combination. Where training is needed, a group of experts will prepare training materials and then trainers will implement the course. In some cases selected participants may be sent on formal courses at third party training facilities.

The current Central Asian project comprises a series of missions. This project highlights the process and outcomes of such abandoned mine programs. This mission showed the benefits of a regional approach addressing cross-border issues.

Members States participating in this IAEA Regional Project were Kazakhstan, Kyrgyzstan, Tajikistan & Uzbekistan. The four member States;

- are interested in managing and/or remediating the legacy of former uranium mining and milling activities to protect their population and environment;
- have similar problems in the same geographical region and under similar climatic conditions; and
- by joining to undertake a regional project gained opportunities for improving cooperation and understanding between the participants; it also offers efficiencies in service delivery for IAEA.

Meetings with the following personnel have contributed to this section; Peter Waggitt, Russell Edge, Shaun Guy, Peter Bartsch, Horst Monken-Fernandez.

Some of the strengths observed in the IAEA abandoned mine program include;

- It is a well established program and has been in existence for more than 20 years.
- The program is supported by direct employment or engagement of consultants with skilled personnel.
- Funding is based on discrete projects with planning commencing about 12 months prior. For Technical Cooperation, concepts arrive 12-18 months before the start of the planning cycle. IAEA work together to develop the projects and workplans before obtaining approval. This is followed by a 2 year implementation cycle extending indefinitely to support missions;
- Funded by member states so there is a strong client focus;
- There are **two** sources of funding;
    - The regular budget is funded from member state subscriptions; and
    - specific projects and tasks funded by extra budgetary contributions or other multi-lateral organisations eg. Kyrgyzstan with world bank, and Norwegian Government as they have agreed to fund upgrading of radiological regulatory network. Extra budgetary contributions from member states are mostly tied to specific projects eg. Turkey will contribute to work within Kyrgyzstan related to regulatory issues or supply equipment, financial aid tied to use of their goods/services)
- No funding for actual rehabilitation works (not the intention – outside statute) but the team can help member states to find funds;
- Clearly defined focus – Uranium sites and NORM management addressing human (community and worker) health and safety and environmental protection;
- Acknowledges principles of sustainability and expect that work will be undertaken in that framework (using same terminology as UMREG – financial, social and economic balance, with safety always assumed)
- Ability to pull together multi-disciplinary teams from within and using external expertise;
- Project leaders have good contacts aiming to run well organised projects to attract other expertise to project;
- Access to other resources within the IAEA uranium cycle team (which provides knowledge of countries, cultures, language across boundaries etc) to help implement projects and programs of work;
- Impartiality and independence held in high regard (high level technical advice);
- Through the UN network they do get opportunities to integrate with other agencies e.g. Health and social aspects for holistic approach through UN family of organisations; integration of work with agencies outside UN "family"

e.g. Organisation for Security and Cooperation in Europe (OSCE), North Atlantic Treaty Organisation (NATO) European Commission (EC)
- After retirement it is possible for employees to be re-engaged as consultants between 62-65 years.

Some of the weaknesses are;
- the IAEA prefer to have consultants who are cost free (eg. other government employees or consultants willing to work for very low fees (travel grant or ticket provided and accommodation is a daily subsistence allowance same as paid to staff) so this relies on the willingness and capacity of those governments/companies to let staff work on missions;
- sometimes the industry expertise needed is not willing to work for the money available especially when the mining industry is booming;
- exploration has been greatly reduced for small projects but major exploration continues so IAEA have trouble attracting expertise they want;
- there is a rotation policy where the majority of professional staff and many general staff are appointed on contracts, from 3 years to a maximum of 7 years depending on age, having to retire strictly at 62 so corporate knowledge lost from IAEA;
- lack of close integrated working with the mining industry in the past, but improving now (has been closer to power utilities in past);
- high turnover/staff movement in member states (not something that can be controlled but has an impact on programs).

There are some opportunities;
- To have longer tenure of personnel providing greater continuity of knowledge and possibly more effective with long term follow through on projects and for member states (in terms of who to contact and developing long term relationships).
- Tap into more 'retired' expertise (would need policy change to make it easier to use expertise of people over 65).
- IAEA are working with world nuclear association (London based nuclear industry mining, power plant, nuclear fuel cycle lobby group/body) to get more mentoring in regulation between seniors and juniors and between developed and developing nations.

Threats include;
- During the current global uranium mining expansion, there is increasing demand for skills, knowledge, projects, yet limited ability to increase budget
- Process taken to get people employed is so delayed that when a boom is detected and recruitment commences, the personnel may not be employed when needed.
- Slow process but also skills shortage (function of 20 years of uranium industry doldrums and ageing workforce) mining industry has also suffered, people who have left the industry and succession planning is less developed than needed.
- Government trained regulators are rapidly recruited by industry in member states, taking skills from regulatory context.

The themes which run through the attributes of IAEA abandoned mine programs have relevance at other levels of government. All projects require project leadership and management, forward planning, multi-disciplinary teams, a strong client focus and risk assessment as well as careful documentation for follow up and review of progress. This planning is undertaken in the context of a skills shortage and

regulatory imbalance. The mining industry often has more access to expertise than regulators due to a range of factors including, but not limited to, remuneration.

ENVIRONET is a network which has been established at the IAEA. This network has a series of partners involved in the development and implementation of technology for remediation of contaminated sites; mostly research laboratories and similar organisations. The aim is to coordinate support to member States, facilitate sharing of knowledge and to create a forum through which experts' advice and technical guidance can be discussed, developed and distributed.

The following is an overview of the role of the IAEA in radiation safety aspects of waste management.

Background to global uranium legacy sites
Uranium exploration, mining and production has been increasing rapidly recently after a long period of inactivity. Since 2003 fears of a production shortfall and spot price increases have led to increased uranium mining activity and a steady increase in long term contract price. Uranium resource development is going on worldwide in over 30 countries. Activity involves both current and former suppliers as well as junior developers and new prospectors with both new and established resources.

Issues
- Uranium resource development is taking off worldwide but many legacy sites remain unremediated.
- Legacy remediation requires a lot of money e.g. Wismut /UMTRA.
- Some former production nations are under economic pressure to restart operations but knowledge and resources, both technical and regulatory, are no longer present.
- Some countries are potential new producers with no local experience and little or no resources for regulation.
- New mining companies will need to respect international standards and the high standards set by current operations.
- All resources, human as well as physical and financial, are in short supply throughout the minerals industry (not just uranium mining) and the expert population is ageing.
- Training is very much needed in many places.

Conclusions
- Uranium mining is an international activity with a global legacy of abandoned and unremediated sites.
- The industry is undergoing a resurgence of activity (at an increasing rate) which is likely to go on for some time.
- Re-development on and around old sites should build in legacy remediation to the greatest extent practicable and lessons learned must be heeded.
- The need for remediation of legacy sites has been recognised and is ongoing, but more resources are needed.
- The main constraint to legacy remediation is funding but human resources are a limiting factor also in most places. Education and training need to be addressed urgently.
- Failure of new developments and/or developers to maintain existing safety and environmental standards could adversely affect expansion of uranium mining.
- Strong and fair regulation is vital for long term success of the uranium mining industry.

- IAEA and others provide support to nations to help ensure that appropriate regulatory systems and safety standards are in place to manage the safe and secure development of all uranium resources.
- Liaison between all the agencies involved is essential.

If a county lacks the regulations to adequately regulate safety or environmental protection of mining then tools need to be developed and member State personnel trained. Often retired regulators provide a valuable resource for these missions.

If developed nations are interested in safety and security of the nuclear industry then customers and other beneficial users (of nuclear power stations) which use resources extracted from uranium mining should pay for it.

Legacy issues related to uranium mill tailings rehabilitation could have been minimised if several key prerequisites were achieved;

- Robust political context with strong and effective regulation,
- Both regulators and mining companies understand key project risks during planning stage,
- Development of solutions using multi-disciplinary teams (e.g. engineering and science with long term vision clearly defined),
- Flexible design to allow for various mine life scenarios strongly influenced by the market value of the mined and processed commodity, and
- Good planning supported by sufficient funds to implement quality solutions.

Thickening of tailings is just one example where, from the perspective of both water conservation and long term closure planning, thickening offers some solutions. It reduces the overall size of an impoundment required to contain tailings, whilst also reducing the overall volume of contaminated water which has the potential to drain from the tailings mass. These impacts are not unique to uranium mill tailings. Other mining types including, but not limited to, those with sulfide rich ores and waste products produce AMD. This causes impacts on ground and surface water quality. Short term operational cost savings, such as the decision to deposit low density tailings in dams, have the potential to leave longer term negative impacts on environments and communities. This is compounded when rehabilitation of the tailings storage facility is not carried out in a timely manner or to a satisfactory standard.

UNESCO – Cornish Mining, World Heritage Site Listing

The outstanding universal value of this landscape was recognized by having 10 areas of Cornwall and West Devon inscribed by the UNESCO as a World Heritage Site in July 2006. A meeting with Ainsley Cocks, Research and Information officer, at the WHS office (CC) provided some background to the heritage listing process.

“This landscape was transformed during the period 1700-1914 by early industrial development that made a key contribution to the evolution of an industrialized economy and society in the United Kingdom, and throughout the world”.[52]

The submission required a significant commitment at a number of levels of government and NGOs (with 16 parties acknowledged) to develop a successful;

- Nomination document,

[52] Corwnall and West Devon Mining Landscape World Heritage Site Management Plan, 2005-2010, Summary, 55pp, Cornwall Council. www.cornishmining.org.uk

- Full management plan, and
- supporting documents including an Economic Impact Assessment, and Marketing Strategy.

Based on 6 brands:

- Innovation and exploration
- Entrepreneurial and progressive
- Authenticity and cultural distinctiveness
- Sustaining the environment and economy
- Mutual endeavour and respect
- Broadening horizons internationally

The WHS listing draws attention to the international significance of mining in Cornwall.

"That is Cornish Mining generated a true "world family", and a landscape and culture that can be experienced internationally. In excess of 250,000 people left Cornwall during the 100 years between 1815 to 1915, giving rise to an estimated 6 million people globally of Cornish descent. There are understood to be in excess of 175 locations internationally with Cornish mining connections and it is our aim to foster relationships with Cornish Mining communities worldwide."

The 'diaspora' gardens within the **Heartlands** project will aim to provide a connection to Australia and other nations who have connections to Cornish mining via migration.

Australia is connected to this project because it was one of several countries where Cornish migration and the associated transfer of mining knowledge and expertise is clearly evident. South Australia's mining heritage trails connect key sites of which the township and attractions of Burra provide evidence of Cornish influence in the remaining engine houses and other features.

4.5.2 NON-GOVERNMENT

Eden Project Post-mining Alliance

The expertise from the Eden Project has been applied via the post-mining alliance to global mining issues. Three examples are provided:

The Core is the education, arts and events hub at the Eden Project. One aspect of this building has international implications for minerals stewardship. In its desire to see sustainable mining supported, the Eden Project decided to use virgin copper for the roof of its education centre and at the same time track the copper from its souce from a mine renowned for its high environmental and social standards, through the production process to installation[53] .Various choices had to be made during this process. The use of Envest (UK Ecopoint score system) to measure overall environmental impact was used with challenges and opportunities discovered. Time frames for durability also needed to be considered. This project evaluated the concept of 'cradle to grave' tracking. Recommendations were made to enrich the Envest system for tracing a metal from its sources. A two year research project has now commenced to extend knowledge of minerals supply chain stewardship. The Eden Project's partnership with Rio Tinto has provided valuable funding.

[53] Eden Project, From Rock to Roof, following the journey of copper, 5 pp brochure

The Post-mining Alliance has also produced a book[54] showcasing an international array of creative post-mining landscapes, demonstrating that many disused mines have great potential for a new kind of wealth. The book acknowledges that we have all played some part in the creation of today's mining legacies and reminds readers that the community must be involved in rehabilitation as well as governments. The author lists key ingredients to successful regeneration as:

- Local solutions to fit local circumstances;
- Leadership, vision and commitment;
- Creative partnerships for funding, development and implementation;
- Collaboration with unusual suspects, developing shared interest;
- Community involvement and consultation at all stages, developing shared responsibility and ownership; and
- Uniqueness, spectacle, good design.

During a presentation at IBA-SEE the director of The Eden Project's Post-Mining Alliance reinforced the need to set an objective of becoming a 'wow destination' when planning innovative post-mining land uses. Sites need to have the largest or longest or biggest feature of its kind to be able to attract attention from a wide audience. The Eden Project's rainforest biome is an example of this. Strong marketing and branding were part of this.

In March 2008 the Post-Mining Alliance planned and coordinated an international legacy site roundtable forum in Toronto, Canada. This was initiated by IUCN and ICMM[55] as part of a longer term dialogue, with the aim of generating solutions to key obstacles to legacy site regeneration and for developed nations to provide leadership to developing nations. Key aspects included;

- Funding and finance;
- Legislation and regulation;
- Partnership approaches and local community participation; and
- Knowledge sharing.

4.5.3 MINING INDUSTRY

The International Network for Acid Prevention (**INAP)** is an industry group created to help meet the challenges of AMD. "INAP exists to fill the need for an international body which mobilizes acid drainage information and experience." Founded in 1998 INAP has become a proactive group providing international leadership.

INAP (together with a Global Alliance) sponsored the development of the GARD (Global Acid Rock Drainage) guide which is now accessible via the web[56].

4.5.4 CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS (INTERNATIONAL)

Conclusions;

- We do not appear to have a national point of contact within Australia regarding abandoned mines. The recent IUCN/ICMM international forum on legacy sites, organized by the Eden Project Post-Mining Alliance, had representation from the Australian mining industry, research and consulting but none from any level of

[54] Post-mining Alliance (2009) 101 Things to do with a hole in the ground, Georgina Pearman
[55] ICMM website library: Roundtable restoration of legacy sites, IUCN & ICMM, 2008
[56] www.gardguide.com

government. This means that as a nation our government is not actively engaged in global dialogues or development of global strategies on abandoned mines. By sharing our government's perspective we can also build capacity in Australia.

- International networks provide opportunities for Australian abandoned mine managers to both learn and to apply knowledge.
- Because there are several Australian's working at the IAEA networking with other Australians involved in abandoned uranium mining occurs readily.
- The abandoned uranium mine network is well organized as is the international AMD network. A global abandoned mine network was considered during the ICMM/IUCN roundtable forum and should be further developed to share knowledge amongst groups working on the same types of challenges. There is also a need to transfer developed nation knowledge to developing nations.
- Opportunities exist to further develop the post-mining land use network and mining heritage tourism networks.
- INAP is a valuable network for those working with AMD because it has the ability to engage global alliance partners as well as industry.
- GARD guide is now available on the web and is making valuable information available to all (industry and government).
- The value of government personnel participating in IAEA missions is perhaps underestimated in Australia. We need to have sufficient capacity to allow this to occur for many reasons; capacity building, robust regulation in Australian, retention of skills /career development as well as participating in the process of developed nations helping developing nations.
- The IAEA model would work well within Australia at a national scale to provide technical advice to states/NT. This could draw on internal and external expertise to build capacity on specific aspects of abandoned mine programs. E.g. the team who undertook the abandoned mine inventory for Western Australia could travel to other states/NT and share their experience to reduce the 'reinvention of wheels' and build on what has been learned. An abandoned mine secretariat could coordinate this function.
- Actively engaging Australian regulatory and abandoned mine management expertise within IAEA missions overseas will also develop skills of Australians. This is important for applying leading practices in Australia.
- Abandoned mine rehabilitation guidance in the form of manuals, leading practice handbooks, toolkits for minesites other than uranium, is not easy to find. Information is dispersed across multiple sources and organizations. This highlights the need for a national point of contact in Australia with capacity to support an 'Australian network on abandoned mines rehabilitation'.

Questions;

- How are State/NT governments ensuring that regulators and abandoned mine managers have access to these opportunities to work on IAEA missions overseas?
- How is Australia preparing for the skills shortage in an expanding uranium sector (regulatory, consulting and industry)?
- How are abandoned mine managers linked to INAP? JK Tech has the role now in terms of running workshops for INAP. This is difficult to determine intuitively for example by searching keywords on the internet. Is there a need for a 'road map' for new abandoned mine managers/teams on where to find out what is going on in Australia with abandoned mine projects, research and training?
- Who will lead a global abandoned mine network to help transfer knowledge from developed nations to developing which was a recommendation of the legacy site roundtable forum IUCN/ICMM in 2008? Will funding be available from the World

Bank to progress the outcomes from this project to develop a strategic plan? Could that funding also enable more detailed documentation, and wide distribution of, the outcomes from the forum including case studies, by Eden Project Post-Mining Alliance? Who will lead the next phase of a global abandoned mine network?

- Find out from SA PIRSA how Australia is responding to the links to Cornish Mining WHS listing. What beneficial opportunities are there for Australia?
- How are we including green energy projects in Australian abandoned mine rehabilitation projects?
- How are we taking pressure off clearing of new land for development when redevelopment of mined land provides an opportunity to effectively rehabilitate and reuse this degraded land?

Recommendations;

1) The Australian Commonwealth government, as well as State/NT governments managing abandoned mines, need to be engaged in international forums on legacy site issues if the benefits of learning from them are to flow through to projects and programs. We need a national point of contact supported by a network to ensure key stakeholders are kept informed. This should be supported by national workshops within Australia to progress priorities.

2) A national point of contact is needed in Australia for abandoned mine management so the innovative developments from overseas can be shared here.

3) Australia needs to have a national abandoned mine network with a clearly defined purpose and point of contact to support and connect individuals and governments involved in rehabilitation of abandoned mines and post-mining land use in Australia.

4) Develop the post-mining land use network and mining heritage tourism networks with a national secretariat for abandoned mines in Australia.

5) Apply the IAEA model at a national level, to provide training and advice within Australia to abandoned mine rehabilitation programs/projects by using both internal government and external expertise. For example; states define an issue they need help with and seek assistance from a national Secretariat, who coordinates teams for clearly defined missions to support States/NT on issues such as development of policy, planning of heritage trails and conservation, AMD, risk management and inventories.

5 SUMMARY OF THEMES AND RECOMMENDATIONS

Specific recommendations are included in each of the sections above, specifically in Sections; 4.1.5, 4.2.4, 4.3.2, 4.4.5 and 4.5.4. Here I have extracted the key themes and recommendations from this report.

Several common **themes** were exhibited by programs overseas. They include;

- innovation and excellence,
- strong leadership,
- clear acceptance of responsibility by governments,
- consistent legislation and regulation,
- clarity of regulatory control with no 'grey areas', supported by sound policy,
- networks and regular forums providing valuable connections,
- sufficient resources – money, skills and data,
- the importance of NGOs,
- the value of broad stakeholder engagement,
- long term vision - having a plan, knowing what is needed and implementing it,
- effective organizational structures with a single point of contact,
- shared focus by different stakeholders ensuring political, personal or physical boundaries become 'invisible',
- transparent performance reporting,
- clear evidence of liability reduction and creation of new opportunities,
- obstacles are overcome in a systematic manner to achieve the project vision,
- creation of landmark projects lead the way for others,
- lessons learned from abandoned mine programs are transferred to industry, governments, researchers, catchment groups and other stakeholders improving the sustainable development of mining at different scales.

Recommendations

In Australia we need;

- High level acknowledgement of abandoned mine liabilities by Governments, and determination to address them. This means;
  - The Commonwealth Government must show leadership by publicly endorsing the Strategic Framework for Abandoned Mines in 2010, ensuring all stakeholders are engaged, and resources are applied to support its implementation; and
  - State/NT governments must ensure they have one lead agency managing abandoned sites and stakeholder engagement.

- Lead agencies must ensure they;
  - have clearly defined abandoned mine policies;
  - have a separate team of personnel, with appropriate skills to manage abandoned mines;
  - support the human and financial resources to project manage the abandoned mine program;
  - undertake a complete inventory of their abandoned mine liabilities within 1-2 years;
  - rectify abandoned mine legacies in a defined time frame, say 10 years;
  - use risk based prioritisation systems to tackle high risks first;
  - include all aspects of sustainability, economic, environmental and social when planning projects and engaging stakeholders;

    - use expert panels with appropriate skills mix, (e.g. environment, industrial archaeology, engineering) to review larger and more complex site planning;
    - complete and make available to the public, biennial performance reports on their abandoned mine programs.
- Within one year, a review of these programs by Auditors-General and plan to review again periodically to ensure full liability accounting and performance reporting at all levels of government, i.e. Commonwealth and State/NT.
- A national forum on abandoned mine management to be lead by the Commonwealth Government in 2010 engaging all State/NT governments and all key stakeholders. Attract keynote speakers from leading practice programs/projects overseas. Use this forum to define roles, responsibilities and time frames for implementation.
- The Commonwealth and State/NT governments as well as the Minerals Council of Australia to establish an abandoned mines secretariat with multi-stakeholder advisory committee to facilitate networking on abandoned mine rehabilitation (including related contaminated land) in Australia. This must ensure links within Australia are established, as well as links to overseas networks so more can be learned about leading practices.
- more emphasis on mining heritage conservation and adaptive re-use of historic mines.
- The Commonwealth Government to initiate an awards program to acknowledge leading practice abandoned mine projects within Australia and attract innovative and unusual stakeholders to support projects.
- A training course on abandoned mine management be run within two years targeted at all stakeholders.
- An abandoned mine toolkit for Australia to be developed within 1-2 years drawing on case studies from overseas and within Australia.
- Have 100% financial assurance for mining projects.
- Ensure ‘polluter pays’ legislation is incorporated into regulatory frameworks for mining where they do not currently exist.
- Explore opportunities to divert a proportion of lottery funds to post-mining land uses where heritage conservation or other development will have a direct socio-economic benefit to communities, and
- More catchment groups engaged in abandoned mine rehabilitation programs.

Australasian Journal of Environmental Management

ISSN: 1448-6563 (Print) 2159-5356 (Online) Journal homepage: https://www.tandfonline.com/loi/tjem20

Transition or transformation: shifting priorities and stakeholders in Australian mined land rehabilitation and closure

Corinne J. Unger, Jo-Anne Everingham & Carol J. Bond

To cite this article: Corinne J. Unger, Jo-Anne Everingham & Carol J. Bond (2020): Transition or transformation: shifting priorities and stakeholders in Australian mined land rehabilitation and closure, Australasian Journal of Environmental Management

To link to this article: https://doi.org/10.1080/14486563.2020.1719440

Published online: 11 Feb 2020.

AUSTRALASIAN JOURNAL OF ENVIRONMENTAL MANAGEMENT
https://doi.org/10.1080/14486563.2020.1719440

Transition or transformation: shifting priorities and stakeholders in Australian mined land rehabilitation and closure

Corinne J. Unger [a], Jo-Anne Everingham [b] and Carol J. Bond [c]

[a]The University of Queensland Business School, University of Queensland, St Lucia, Australia; [b]Centre for Social Responsibility in Mining, Sustainable Minerals Institute, The University of Queensland, St Lucia, Australia; [c]School of Management, RMIT University, Melbourne, Australia

ABSTRACT

This article is a retrospective study of the shifting priorities and stakeholders over the last four decades of Australia's mine rehabilitation and closure practices. We map the evolution of knowledge, stakeholder involvement, and community awareness of mining socio-environmental risks and impacts to show how mine rehabilitation and closure practices have evolved over time. We conclude that shifting priorities have transitioned through three phases as understandings of the priorities for successful closure evolved. An initial focus on biophysical rehabilitation within the boundaries of individual mines has extended to currently attend to management of risks that extend beyond the boundaries and include social dimensions. These practices are guided by a desire for improved engagement processes and agreement on outcomes for post-mining landscapes.

KEYWORDS

Mine rehabilitation; mine closure; legacy risks; liability; stakeholder engagement

Introduction

Australia has a mixed mining legacy. Mining has been an economic powerhouse for Australia for over 100 years. Nevertheless, mining is a 'temporary land use' generating wealth, jobs, and opportunities that do not last. The temporary land use also generates environmental consequences: degradation of productive, multi-functional land; generation of waste rock and tailings; and, changes to the quality, level, availability and flow of surface and ground water. Communities are increasingly aware and critical of these social and environmental consequences and mining legacies.

Mining standards and practices of companies and governments are subject to scrutiny across a range of issues. These include: proliferation of abandoned mines; unproductive mines either in 'care and maintenance' or in the control of perceived 'fly-by-night' companies; and large, long-life mines approaching depletion (Mudd 2010, 2013; Wright et al. 2011; Unger et al. 2012; Unger et al. 2015; Ashby, van Etten, and Lund 2016). These critical issues fuel a growing desire, by a wide range of stakeholders, to achieve effective rehabilitation, closure and relinquishment of Australia's mines. Greater attention to end of mine life applies to the range of mines in Australia including those of large multi-national

CONTACT Corinne J. Unger c.unger@business.uq.edu.au

corporations, those owned by wealthy individuals, and smaller second and third tier companies, both publicly listed and private.

We have organised the article into three sections to address the research question: *how have priorities and stakeholders in Australia's mine rehabilitation and closure (MR&C) practice shifted over the last four decades?* The first section defines the concepts and terms relating to 'rehabilitation' and 'closure'. The second section identifies the range of stakeholder groups engaged in MR&C. The third section reviews the changing priorities and identities of influential stakeholders while summarising key practices of MR&C associated with three phases. The article concludes with implications for current Australian MR&C policy and practice in alignment with current stakeholders and priorities.

Defining the terms of the study

In describing this study, it is important to be clear on terminology. In Australia, *mine closure planning* is defined as 'a process that extends over the mining life-cycle and that typically culminates in tenement relinquishment, includes decommissioning and rehabilitation' (Australian Government 2016a, 110). The term *mine closure,* in contrast, is used to 'indicate the point at which operations cease, infrastructure is removed and management of the site is largely limited to monitoring' (Australian Government 2016a, 110). *Rehabilitation* describes the biophysical repair of the landscape (Doley and Audet 2013; Australian Government 2016b). The International Council on Mining and Metals uses *closure* and *progressive closure* (ICMM 2019) rather than closure and progressive rehabilitation, because progressive tasks during operations that prepare for closure are not limited to rehabilitation.

Despite the definitions above, there is no consistent use of these terms either by stakeholders or across time within the Australian context. A persistent issue is that the terms *mine rehabilitation* and *mine closure* are conflated, creating ambiguity. Consequently, new terms have been introduced. The term *restoration* is used to describe processes assisting the recovery of ecosystems in preference to the more generic term *rehabilitation* (Society for Ecological Restoration Australasia 2017; Society for Ecological Restoration 2004; Cross et al. 2018). In addition, terms such as *regeneration* (Kuhn and Liebmann 2007, 123; Whitbread-Abrutat, Kendle, and Coppin 2013, 629) and *revitalisation* (Kaźmierczak, Lorenc, and Strzałkowski 2017, 697) are emerging to describe the process of counteracting socio-economic decline due to mine closure or abandonment. This links to belated attention to the social aspects of closure (Bainton and Holcombe 2018a, 2018b).

Finally, the term 'stakeholders' also requires definition. In this article we use Freeman's (1984, 46) classic definition: 'any group or individual who can affect or is affected by the achievement of the organization's objectives'. Five stakeholder groups are identified in this article as relevant to the management of MR&C.

Stakeholders influencing MR&C in Australia

The first stakeholder group is industry peak bodies and industry practitioners, whether working within companies or as consultants. Industry peak bodies represent the views of member companies. Examples include: the Minerals Council of Australia (MCA), MCA-affiliated or independent state counterparts, and the International Council on

Mining and Metals (ICMM). Industry practitioners are those actually doing MR&C. They may also be members of professional bodies such as the Australasian Institute of Mining and Metallurgy (AusIMM), Environment Institute of Australia and New Zealand, and Engineers Australia.

The second stakeholder group includes state and territory governments responsible for the regulation of MR&C. There is considerable variation in the terminology and focus of legislation from one jurisdiction to another. In addition, there is variable attention to issues including: closure, legacy risks and financial provisioning, though there is a convergence of rehabilitation goals toward safe, stable, non-polluting and sustainable post-mining land uses.

The third stakeholder is the Australian, national government. Although states and territories in Australia have primary responsibility for mining oversight, the Australian government is involved to a limited extent in domestic and global rehabilitation and closure practice of mining operations and abandoned mines (Australian Government 2016d; Laurencont 2014). Within Australia, the Australian government has responsibility over: mines formerly owned by government (Northern Territory Department of Mines and Energy 2013), uranium mining policies (Energy Resources of Australia 2013; Australian Government 1980), Indigenous agreements (O'Faircheallaigh 2006), national environmental protection standards (Australian Government 2013) and regulation of radiological aspects by the Australian Radiation Protection and Nuclear Safety Agency (Australian Government 2018a). Globally, the Australian government participates in international forums and signs international treaties of relevance to MR&C, such as the Minimata Convention on mercury, a legacy impact from historic gold mining (Australian Government 2016c). The Australian Government also supports MR&C research, for example, through the Australian Nuclear Science and Technology Organisation (ANSTO) and, intermittently, through the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The fourth stakeholder group is comprised of international organisations. These organisations have spurred a proliferation of voluntary, self-regulation activity that applies standardised sustainability indicators to encourage companies to report on their performance. The range of institutions developing such measureable indicators include the World Bank, the International Finance Corporation (IFC), and the Global Reporting Initiative (GRI) (Global Reporting Initiative 2016; Bond 2014; Evans and Kemp 2011). These initiatives create benchmarks for mining sector performance for MR&C financial assurance (to guarantee funds are available for rehabilitation and closure), impacts on biodiversity, water and livelihoods, pollution and environmental management (Equator Principles Association 2013; Lance 2013; Sassoon 2009).

The fifth stakeholder group is that of community stakeholders distinct from governments and commercial organisations that have exerted influence mainly though non-government organisations (NGO) and research institutions. Examples include: Environmental Defenders Office, Sunrise Project, the Australia Institute and Lock the Gate, as well as research groups specifically engaging in knowledge generation and sharing. Within this category are a more disparate group of local stakeholders. These local actors include local government, Indigenous landholders, local communities and neighbours. These local stakeholders have little formal role in MR&C, beyond the public consultations mandated at project approval stage; yet locals bear the consequences of mining legacies.

Having defined terms and distinguished between stakeholders, we now categorise three phases of priorities in practice in Australian MR&C. As we explore the phases below, we concentrate on practices of industry and organisational actors distinguishing international initiatives from Australian ones.

Phases within MR&C practice over 40 years

The centrepiece of this section is the 40-year timeline tracing prominent initiatives and developments by different stakeholders in MR&C primarily in Australia but also overseas (Figure 1). From an initial scientific focus on soils and vegetation, three phases of practice reveal the incorporation of additional dimensions of MR&C practice as the decades progressed. The timeline represents the activity of each primary stakeholder group with an interest in MR&C, using shaded shapes. The analysis contrasts *continuing* MR&C activities with those that are *discontinued*. Notably, some early examples of sophisticated MR&C practice remained isolated instances rather than part of overall trends, and as such are marked as outliers.

We characterise the three phases in colloquial terms: Kicking Dirt (1970s–1980s); Outside the Fence (1990s–2005); and Pass the Parcel (2005–present).

Phase 1: the 1970s and 1980s – 'Kicking dirt'

'Kicking dirt' is a term used to describe the practice of mine rehabilitation professionals getting together onsite to discuss rehabilitation challenges in the field. It describes an initial phase in Australian MR&C activity when the main initiatives came from mining professionals who formed regional groups and hosted workshops to build on sharing technical knowledge between professionals. At this stage, most mines were mid-scale, remotely located, and Australian-owned. With the exception of a few open cut mines, underground mining methods were more common until the 1950s. After that, open cut mining in Queensland, and elsewhere, created a larger disturbance footprint comprised of waste rock, tailings and final voids (Wilson 2018). During the 1970s practitioners, governments and Australia's national mining industry body responded to the increasing mine disturbance footprints. The four main developments during this phase are described below.

(1) Soil conservation and agricultural land uses

Primary production in the 1970s meant that Australia functioned largely as a farm and a quarry with agriculture and mining as the big industries (Harcourt 2007). Therefore, agricultural land uses and soil conservation were a focus of rehabilitation practice in response to the creation of large tracts of degraded and unproductive land caused in part by farmers' and miners' clearing of native vegetation and made worse by droughts, floods, dispersible subsoils, and invasive plant species (Mitchell 1991). These were the formative years of the science of mined land rehabilitation resulting in practical handbooks for professionals (Australian Mining Industry Council and RP Warren Environmental Consulting Services 1989; Hannan 1995, 1984). Therefore, this first phase focused initially on 'soil and vegetation cover'.

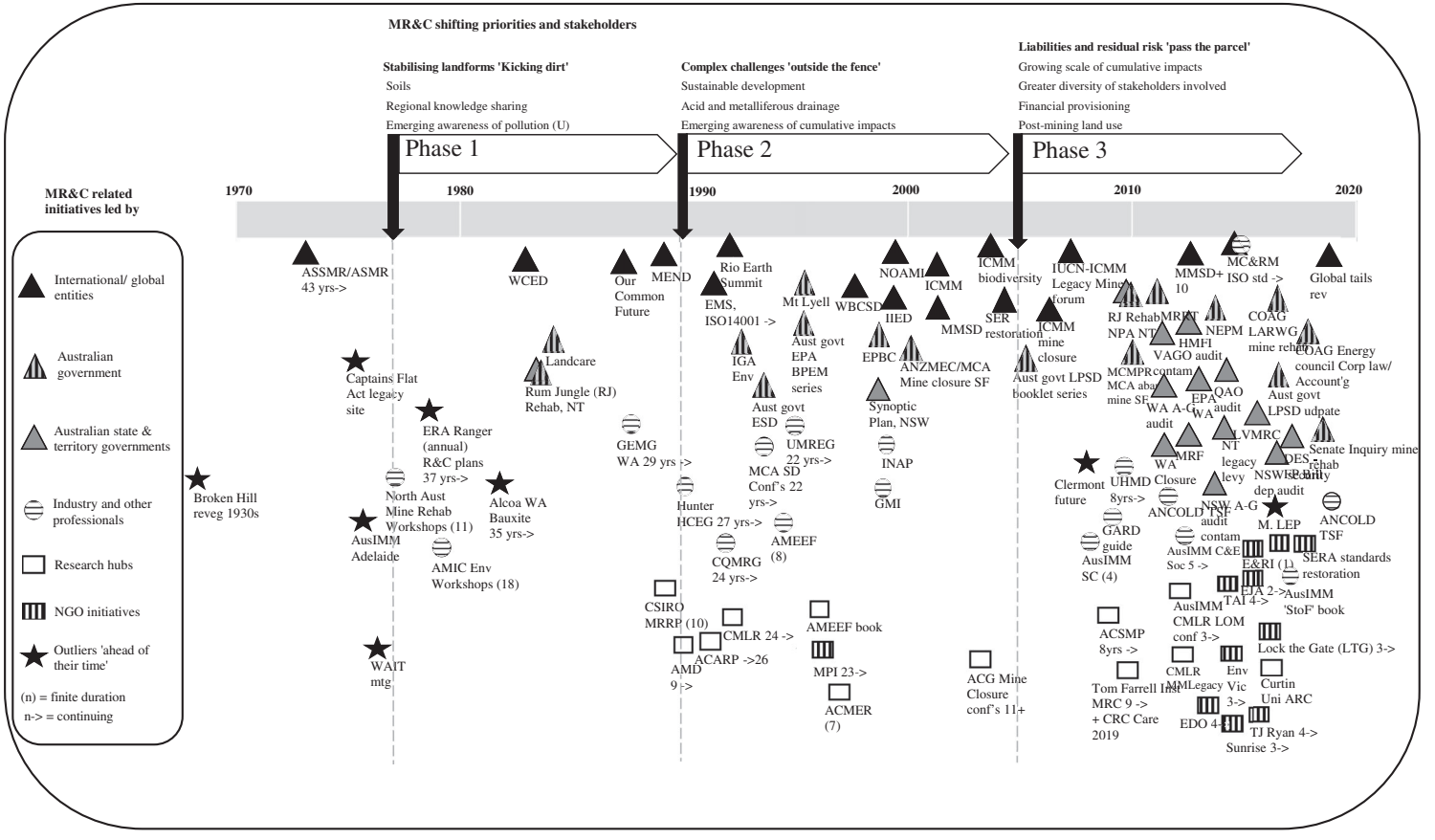


Figure 1. Significant mine rehabilitation and closure influencing initiatives: ~1977–2019 (see Table 1 for explanation of abbreviations and sources).

Table 1. Abbreviations and sources used in Figure 1.

Abbreviation	Explanation and link to relevant source if available
ACARP	Australian Coal Association Research Program https://www.acarp.com.au/
ACG	Australian Centre for Geomechanics, UWA Mine closure conferences http://acg.uwa.edu.au/mine-closure/
ACMER	Australian Centre for Mining Environmental Research
ACSMP	Australian Centre for Sustainable Mining Practices http://www.acsmp.unsw.edu.au/
AMD	Acid and metalliferous Drainage – Australian AMD conferences held every three years since 1990 https://smi.uq.edu.au/event/104/9th-australian-acid-and-metalliferous-drainage-workshop
ANCOLD TSF	Australian National Committee on Large Dams: Guidelines on tailings dams – planning, design, construction, operation and closure. The 2012 guideline has recently been updated in 2019 (Revision 1) https://www.ancold.org.au/?product=guidelines-on-tailings-dams-planning-design-construction-operation-and-closure-may-2012
AusIMM	The Minerals Institute – professional body http://www.ausimm.com.au/ https://www.ausimm.com.au/content/docs/abandoned_mine_management_in_australia.pdf
AusIMM Adelaide	Workshop on landscaping and land use – planning as related to mining operations March–April (AusIMM 1976) Adelaide Branch
AusIMM StoF	Start to Finish: Life of Mine Perspective Spectrum 24, 2018 (McCullough et al. 2018) https://www.ausimm.com.au/publications/publication.aspx?ID=17564
AMEEF	Australian Minerals and Energy Environment Foundation book on Environmental management in the Australian minerals and energy industries: principles and practices (Mulligan 1996)
AMIC	Australian Mining Industry Council (later became MCA)
ANZMEC /MCA	Australian and New Zealand Minerals and Energy Council, Minerals Council of Australia, Strategic Framework for Mine Closure http://www.sernageomin.cl/pdf/mineria/cierrefaena/DocumentosRelacionados/Strategic-Framework-Mine-Closure.pdf
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) Australian and New Zealand guidelines for fresh and marine water quality http://www.agriculture.gov.au/water/quality/nwqms
ASSMR/ ASMR	American Society for Surface Mine Reclamation (ASSMR), later, American society of mining and reclamation (ASMR) rehabilitation focus on coal mined lands initially, later, all forms of reclamation. http://www.asmr.us/
BPEM	Best practice Environmental Management – series of booklets published in 1990s by Australian government EPA
Broken Hill revegetation	Broken Hill NSW includes in its heritage listing (Australian Heritage Council 2015) its 1930s pioneering revegetation 'green belts' for dust control (McIlveen and McNally 1996) and chronology of plantings by Albert and Margaret Morris http://www.aabr.org.au/aabr/wp-content/uploads/2017/04/ShortSummary-BrokenHillRegenScheme.pdf
C&E Society	Community and Environment Society of the AusIMM from 2013 (followed Sustainability Committee 2009 to 2013) https://www.ausimm.com.au/content/default.aspx?ID=344
Clermont	Clermont township in Central Queensland initiated a preferred futures strategy in 2008 to build resilience to mine closure http://www.mdpi.com/2079-9276/2/4/528/htm (Richard, Aleta, and Kieren 2013)
CMLR	Centre for Mined Land Rehabilitation, Sustainable Minerals Institute The University of Queensland https://www.cmlr.uq.edu.au/
COAG	Council of Australian Governments
COAG Energy Council	Energy Council agrees to examine mine clean-up rules http://www.miningreview.com.au/news/coag-energy-council-agrees-examine-mine-clean-rules/
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, based at the University of Newcastle, now involved in annual rehabilitation conferences in the Hunter Valley with the team of the former TFI https://www.minedlandrehab.com.au/
CSIRO MRRP	Commonwealth Scientific and Industrial Research Organisation – Minesite Rehabilitation Research Program, under the Division of Soils Adelaide.
Curtin Uni ARC	Australian Research Council Industrial Transformation Training Centre for Mine Site Restoration (CMSR) http://arc-cmsr.org/index.php/en/
DES FP Bill	Queensland Department of Environment and Science, Financial Provisioning Bill https://www.legislation.qld.gov.au/view/html/bill.first/bill-2018-017
EDO	Environmental Defenders Office (Qld) from 2014 https://www.edoqld.org.au/edo_qld_s_submission_on_discount_criteria_for_mining_rehabilitation_obligations
E&RI	Energy & Resources Insights report: The hole truth: the mess coal companies plan to leave in NSW, 2016 (Energy & Resource Insights 2016) http://downloads.erinsights.com/reports/the_whole_truth_LR.pdf
EJA	Environmental Justice Australia, 2016 https://envirojustice.org.au/sites/default/files/files/EJA_Dodging_clean_up_costs.pdf

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
EnvVic	Environment Victoria 2014, Preventing the preventable, policy options for accelerating coal mine rehabilitation and creating jobs in the Latrobe Valley http://environmentvictoria.org.au/wp-content/uploads/2016/07/Preventing-the-Preventable.pdf
EMOS	Environmental Management Overview Strategy (EMOS) introduced to the Queensland Mineral Resources Act early 1990s
EMS	Environmental Management Systems (ISO 14001 Environmental Management Systems) http://www.iso14001.com.au/iso-14001-standard.html
EPA WA	Environmental Protection Authority of Western Australia – Cumulative impacts of mining in the Pilbara (Vogel 2014) http://www.epa.wa.gov.au/sites/default/files/Publications/Pilbara%20s16e%20advice%20%20270814.pdf
EPBC	Environmental protection and biodiversity Conservation Act 1999 (EPBC Act) Australian government's central environmental legislation http://www.environment.gov.au/epbc
ERA	Energy Resource of Australia, Ranger Mine http://www.riotinto.com/energyandminerals/energy-resources-of-australia-ltd-4711.aspx
ESD	Ecologically Sustainable Development, National Strategy, Australian government, Department of the Environment and Energy http://www.environment.gov.au/about-us/esd/publications/national-esd-strategy
GARD (guide)	Global Acid Rock Drainage Guide http://www.gardguide.com/index.php?title=Main_Page
GEMG	Goldfield Environmental Management Group http://www.gemg.org.au/
Global Tails Rev	Global Tailings Review, collaboration between ICMM, UN Environment and PRI, in response to the catastrophic failure of a tailings storage facility in Brumadinho, Brazil on 25 January 2019. https://globaltailingsreview.org/
GMI	Global Mining Initiative, 2000 https://www.icmm.com/website/publications/pdfs/governance/global-mining-initiative/106.pdf
HCEG	Hunter Coal Environment Group Inc http://www.hceg.com.au/
HMFI	Hazelwood Mine Fire Inquiry 2014 – initial inquiry http://report.hazelwoodinquiry.vic.gov.au/ and 2016 Mine rehabilitation inquiry http://hazelwoodinquiry.vic.gov.au/wp-content/uploads/2015/09/Hazelwood-Mine-Fire-Inquiry-Report-2015-2016-Volume-IV-%E2%80%93-Mine-Rehabilitation-web.pdf
IUCN-ICMM	International Union for the conservation of nature & ICMM legacy mine roundtable forum (2008) (Post-Mining Alliance, IUCN, and ICMM 2008) https://www.iucn.org/theme/business-and-biodiversity/our-work/business-partnerships/international-council-mining-and-metals http://www.icmm.com/website/publications/pdfs/511.pdf
ICMM	Planning for integrated mine closure (2008) https://www.icmm.com/en-gb/environment/mine-closure/planning-for-integrated-mining-closure Good practice biodiversity https://www.icmm.com/website/publications/pdfs/biodiversity/good-practice-mining-and-biodiversity
IIED	International Institute for Environment and Development https://www.iied.org/mining-minerals-sustainable-development-mmsd https://www.iied.org/about
IGA on Env.	Intergovernmental Agreement on the Environment, 1 May 1992 http://www.environment.gov.au/about-us/esd/publications/intergovernmental-agreement
INAP	International Network for Acid Prevention, http://www.inap.com.au/
ISO	International Organisation for Standardisation https://www.iso.org/standards.html e.g. Environmental Management systems ISO14001
Landcare	The name 'Landcare' evolved in Victoria through an initiative of Joan Kirner, (then Minister for Conservation, Forests and Lands) and Heather Mitchell, (then President of the Victorian Farmers Federation). https://landcareaustralia.org.au/about/the-landcare-story/
LTG	Lock the Gate mine rehabilitation campaign http://www.lockthegate.org.au/minerehab
LOM	Life of Mine conferences, commenced in 2012 and are hosted by AusIMM and CMLR, every 2 years. LOM2016 link – http://www.lifeofmine.ausimm.com.au/
LVMRC	Latrobe Valley Mine Rehabilitation Commissioner – statutory office to monitor and audit mine rehabilitation and consult local communities under the Mineral Resources (Sustainable Development) Amendment (Latrobe Valley Rehabilitation Commissioner) Bill 2017 https://www.lvmrc.vic.gov.au/
MAC	Mining Association of Canada
MCA	Minerals Council of Australia
MC&RM	Mine Closure and Reclamation Management ISO standard in progress ISO/TC 82/SC 7 https://www.iso.org/committee/5052041.html
MCMPR	Ministerial council on Minerals and Petroleum Resources (now part of COAG energy council) http://www.coagenergycouncil.gov.au/
MEND	Mine Environment Neutral Drainage http://mend-nedem.org/default/

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
M. LEP	Muswellbrook Shire Council, NSW LEP (Local Environmental Plan) discussion paper (Muswellbrook Shire Council 2017) https://muswellbrook.nsw.gov.au/index.php/component/edocman/?task=document.viewdoc&id=1457&Itemid=0
MML	Managing Mining Legacies forum hosted by CMLR 2012 at University of Queensland following LOM 2012
MPI	Mineral Policy Institute http://www.mpi.org.au/ Mining legacies initiative
Mt Lyell	The Mount Lyell Remediation Research and Demonstration Program in 1995 – Tasmanian and Australian government funded strategy for remediating environment effects of past mining at Mount Lyell in Tasmania
NEPA	National Environmental Protection Authority (Australia)
NEPM	National Environmental Protection Measures, 2013 http://www.nepc.gov.au/nepms/assessment-site-contamination
NOAMI	National Orphaned/Abandoned Mine Initiative (Canada) http://www.abandoned-mines.org/en/
Our Common Future	Brundtland Report 'Our Common Future' 1987, following the 1983 World Commission on Environment and Development (WCED) http://www.sustainabledevelopment2015.org/AdvocacyToolkit/index.php/earth-summit-history/historical-documents/92-our-common-future
LARWG	Land Access for Resources Working Group, under COAG
LPSD	Leading Practice Sustainable Development series of booklets https://industry.gov.au/resource/programs/lpsd/pages/lpsdhandbooks.aspx
LTG	Lock the Gate Alliance http://www.lockthegate.org.au/
MIRECO	Mine Reclamation Corp of South Korea http://www.mireco.or.kr/html/english/01_sub/sub01_01.jsp
MML	CMLR Managing Mining Legacies 2-day forum in 2012, following AusIMM/CMLR Life-of-Mine-Conference in Brisbane
MMSD	Mining Minerals and Sustainable Development Project by IIED https://www.iied.org/mining-minerals-sustainable-development-mmsd
MMSD + 10	Mining Minerals and Sustainable Development Project review after 10 years by IIED http://pubs.iied.org/16041IIED/
MRF	Mine Rehabilitation Fund, Western Australian government http://www.dmp.wa.gov.au/Environment/What-is-the-MRF-19522.aspx
MRRT	Minerals resource rent tax (MRRT) is a 'tax on certain profits generated from iron ore, coal, anything produced by in situ consumption of coal or iron ore, coal seam gas extracted as a necessary incident of coal mining or from a proposed coal mine' https://www.ato.gov.au/Business/Minerals-resource-rent-tax/ The MRRT replaced the Resource Super Profits Tax (RSPT) 2010 which was applicable to all companies at a higher headline tax rate.
NAMRW	North Australian Mine Rehabilitation Workshops – eleven held in total (#11, Jabiru, NT)
NSW AO	New South Wales Audit Office Volume six 2012 Environment, water and regional infrastructure http://www.audit.nsw.gov.au/ArticleDocuments/255/01_Volume_Six_2012_Full_Reportv3.pdf.aspx?Embed=Y Managing contaminated sites (2014) http://www.audit.nsw.gov.au/news/managing-contaminated-sites Mining rehabilitation security deposits (2017) http://www.audit.nsw.gov.au/publications/latest-reports/mining-rehabilitation-security-deposits
NT Legacy levy	Northern Territory government Legacy Levy, 2013, under the Mining Management Act https://dpir.nt.gov.au/mining-and-energy/mine-rehabilitation-projects/about-legacy-mines/levy-and-security
QAO	Queensland Audit Office, 2014 Environmental regulation of the resources and waste industries (report 15:2013-14) https://www.qao.qld.gov.au/reports-parliament/environmental-regulation-resources-and-waste-industries
Rio Earth Summit	United Nations conference on Environment and Development (1992) http://www.un.org/geninfo/bp/enviro.html
RJ	Rum Jungle copper and uranium mine remediation – first undertaken in the mid-1980s with further work initiated around 2011 under an NPA (National Partnership Agreement) between Australian government and the NT government
SER	Society for Ecological Restoration, Primer (2004) defining ecological restoration https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/ser_publications/ser_primer.pdf
SERA	Society for Ecological Restoration Australasia http://www.seraustralasia.com/, National Standards for the practice of ecological restoration in Australia (2016) http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf, National Standards for the practice of ecological restoration in Australia 2nd edition (2017) http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf
SC AusIMM	Sustainability Committee of the AusIMM (preceded the C&E Society)

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
Sunrise	Sunrise Project-engaged with abandoned mine issues from 2015 and mine rehabilitation of coal mines from 2016, https://sunriseproject.org.au/wp-content/uploads/2018/05/2015-Sunrise-Project-Annual-Report.pdf https://sunriseproject.org.au/wp-content/uploads/2018/05/2016-Sunrise-Project-Annual-Report.pdf
Synoptic Plan	Synoptic plan: integrated landscapes for coal mine rehabilitation in the Hunter Valley of NSW prepared by Andrews.Neil for Department of Mineral Resources, 1999
TAI	The Australia Institute – MR&C begins to be included from 2014 http://www.tai.org.au/sites/default/files/TAI%202014%20Warkworth%20Continuation%20PAC%20submission.pdf
TFI	Tom Farrell Institute, University of Newcastle mine rehabilitation conferences – 8 hosted to 2018 http://www.tomfarrellinstitute.org/2017-mine-rehab-conference.html http://www.tomfarrellinstitute.org/
T J Ryan	T J Ryan Foundation began engaging with mine rehabilitation and legacy issues in 2016, co-hosting a mine rehabilitation forum in 2017 with Royal Society of Qld http://www.tjryanfoundation.org.au/cms/page.asp?ID=1488
UHMD	Upper Hunter Mining Dialogue – multi-stakeholder forum to minimise cumulative impacts of mining – MR is one of 10 environmental aspects included. http://www.nswmining.com.au/dialogue/home
UMREG	Uranium Mine Remediation Exchange Group http://umreg.net/ https://www.iaea.org/publications/8404/the-uranium-mining-remediation-exchange-group-umreg
VAGO	Victorian Auditor General's Office (2011) Managing contaminated sites, audit report; https://www.parliament.vic.gov.au/papers/govpub/VPARL2010-14No90.pdf
WA AG	Western Australian Auditor General's Report, Report 8, September 2011 Ensuring compliance with conditions on mining https://audit.wa.gov.au/wp-content/uploads/2013/05/report2011_08.pdf
WAIT	Western Australia Institute of Technology later merged with WA school of Mines, Agricultural college and others to eventually transition to Curtin University http://about.curtin.edu.au/who/history/wa-institute-technology/
WBCSD	World Business Council for Sustainable Development http://www.wbcsd.org/
WCED	World Commission on Environment and Development https://sustainabledevelopment.un.org/milestones/wced

(2) Networking and knowledge sharing

By the late 1970s, mine rehabilitation professionals in Australia recognised the value of sharing mine rehabilitation knowledge to achieve rehabilitation goals. They convened multi-lateral groups of stakeholders including the following. The North Australian Mine Rehabilitation Workshop, organised by volunteers from industry and government, continued for eleven years. The Australian Mining Industry Council initiated an annual environmental workshop that continued until the 1990s when it transitioned into the MCA's Sustainable Development conference. During the 1980s additional regional groups formed in the Hunter Valley coal mining region, the WA Goldfields and Central Queensland, which have continued to the present.

(3) Environmental concerns – particularly pollution

Ecological influences on MR&C emerged in both Australia and around the world in the 1980s. In 1982, Greening Australia was founded to protect, restore and conserve Australia's native vegetation. From the outset, this organisation was engaged in mine rehabilitation, with one company citing a 29-year environmental conservation and sustainability partnership (*Growing stronger together* 2011, 10). A parallel organisation, Landcare, was born in the mid-1980s. Landcare encouraged landholders to work 'in their own social group to solve their own local land conservation problems in their own way'

(Curtis et al. 2014, 177). Landcare was applied to productive farming as well as catchment and biodiversity protection.

Environmentalism gained global momentum in the 1980s contributing to a heightened awareness of industrial pollution amongst MR&C practitioners. However, that awareness was not always translated into action in a timely manner in Australia (O'Riordan 1999). In contrast, the USA enacted the *Surface Mining Control and Reclamation Act* 1977 (SMCRA) for coal mines (US Government 1977 in sub-chapters 2–9). While Australia did not adopt national measures like SMCRA, Australian practitioners did connect at an individual level with the American Society for Surface Mine Reclamation which influenced the thinking of Australian practitioners.

Toward the end of Phase 1, the global mining sector recognised the pollution of acid and metalliferous drainage (AMD) from mining operations. The Canadian government, supported by industry (Mining Association of Canada), recognised the value of cross-jurisdictional technical knowledge sharing about AMD problems. For example, the Canadian Natural Resources agency hosts the Mine Environment Neutral Drainage program (MEND/NEDEM 2019). In Australia, the AMD legacy impacts of several historic mines, like Mount Morgan, Queensland (Unger et al. 2003), and Mt Lyell, Tasmania (John Miedecke and Partners Pty Ltd 1996), became clear as they approached the end of production. An inaugural AMD forum, held in Tasmania in 1990, recognised the need for greater technical exchange among professionals and researchers to improve practices.

(4) Concern about uranium mining legacies

The Australian government took a leadership role in MR&C when proposals for new uranium mines emerged in the 1970s, during the height of international nuclear non-proliferation concerns. When the Ranger Uranium Mine was approved the related Fox Inquiry (Fox 1976, 1977) drew attention to historical uranium mine legacies. Specifically, during the late 1970s the Australian government committed to investigate environmental legacies associated with the former Australian government-owned Rum Jungle copper and uranium mine in the Northern Territory; leading to the first phase of this mine's rehabilitation in the 1980s (Richards, Applegate, and Ritchie 1996)

Summary

These four developments show Australians focused on local and regional, empirically-based, technical-environmental aspects of MR&C such as revegetation, and soil conservation. Practitioners also recognised that research and knowledge sharing between professionals were valuable in mining regions. This first phase saw initial action on challenging issues, such as AMD and mining legacies, as disparate initiatives. However, these relied on insightful leadership often from rehabilitation professionals rather than a systematic approach led by regulatory authorities.

The positive developments from this time include sound knowledge-building by practitioners, supported by the development of manuals and texts, to improve soil and spoil management practices for agricultural uses. 'Outlier' mining companies in Western Australia and the Northern Territory committed to a long-term investment in rehabilitation research to support native ecosystem re-establishment (Koch and Hobbs 2007; McNally, Unger, and Peters 1996; Koch 2015). Finally, this phase saw the formation of

regional rehabilitation knowledge-sharing groups of practitioners, some temporary and some persisting.

Phase 2: the 1990s to 2005 – complex challenges 'outside the fence'

From roughly 1990, advances in technology enabled deeper and larger open-cut mines and rapid expansion in production (Mudd 2009). With these changes, a second phase mirrors the growing complexity of MR&C practice with increased recognition that mines have the potential to affect environments and communities beyond their spatio-temporal boundaries. The acknowledgment of issues emerging 'outside the fence' extended the scope of responsibility and potential liability for governments, MR&C professional bodies and mining operations.

Recognition of common global problems related to large-scale mining encouraged further organised knowledge sharing on prominent issues of rehabilitation according to principles of ecologically sustainable development (ESD) (Buckley 1992; Brundtland 1987; Needham 1999). Australia connected more substantially with global initiatives and organised knowledge-sharing on specific issues such as AMD. Mitigating and managing geochemical and biodiversity risks came to prominence during this phase. Investing in research became more common, and 'linear systems' to manage environmental risks were introduced. While biodiversity became a more significant goal for mine rehabilitation by state regulators, Australians did not follow the lead of overseas examples on abandoned mines and mining legacies where national initiatives built knowledge that supported the professionals managing state/provincial abandoned mine programs. Four prominent Phase 2 developments in MR&C are described below.

(1) New scientific disciplines to mitigate cumulative environmental problems

During this phase, soil scientists lost their prominence and companies turned to new disciplinary expertise to address cumulative and long-term problems of waste and water management. For example, ecologists promoted the return of biodiversity to mined land and *closure* became more formalised (Mulligan 1996, 2014; Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia 2000; Cummings 2014). Meanwhile, geochemists focussed their attention on AMD guided by the initiatives of international organisations and local consulting expertise. The MEND program in Canada, mentioned in Phase 1, extended its collaboration to initiate a series of international AMD conferences. The International Network for Acid Prevention (INAP) was formed in 1998 and this group later coordinated the development of the online Global Acid Rock Drainage (GARD) guide. Finally, social scientists raised awareness of the influence and significance of stakeholder acceptance by communities not just industry and government (Owen and Kemp 2013).

Following the International Society for Ecological Restoration's (SER) definition for ecological restoration as 'the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed', the Australian society (SERA) developed a standard for ecological restoration with six key principles (Society for Ecological Restoration 2004, 3). These guided *restoration* as the activity to deliver *recovery*, as the outcome sought (Society for Ecological Restoration Australasia 2017, 2).

(2) National and state ESD regulation and an SD focus for mining

Global events such as the World Commission on Environment and Development (WCED) and the Rio Earth Summit encouraged the Australian government to adopt Ecologically Sustainable Development (ESD) policies. The mining industry also embraced the ESD concept with mining executives in the World Business Council for Sustainable Development (WBCSD) forming the Global Mining Initiative (GMI) to undertake a rigorous study of the socio-environmental issues facing the mining industry. The Mining Minerals and Sustainable Development (MMSD) initiative outlined the way to apply Sustainable Development (SD) to the mining industry. MMSD interpreted ESD as requiring a *triple bottom line* approach, not only demonstrating environmental sustainability but also social and economic sustainability (Elkington 1997; Mining Minerals and Sustainable Development Project 2002). The GMI and MMSD led to the formation of the International Council on Mining and Metals (ICMM) which developed guidance and support for member companies seeking to reform the environmental and social performance of mining (International Council on Mining & Metals 2006).

The United Nations Conference on Environment and Development (UNCED) Earth Summit Conference, held in 1992, sought to reconcile worldwide economic development with protection of the environment. Members of the UN, including Australia, committed to pursue economic development in ways that protected the environment and non-renewable resources. From this forum, Agenda 21 outlined global strategies for mitigating and managing environmental harm (United Nations Conference on and Development 1993). Part of this agenda recommended strengthening of legal and institutional capacity as well as consultative processes because of the importance of local government and involvement of communities in sustainable development. Reinforced by these initiatives, integrated catchment management in Australia adopted a regional governance model with involvement beyond government. Landcare, founded as a volunteer organisation during Phase 1, now required funded programs and strategic regional support that was more comprehensive. This led to NRM (Natural Resource Management) bodies in a multi-level 'nested' governance structure comprising multiple Landcare groups that formed Landcare networks, within catchment management groups (Curtis et al. 2014, 187). In addition to integrated catchment management, strategic catchment activity addressed legacy mine rehabilitation. Examples include support by the Fitzroy Basin Association, for water treatment at Mount Morgan historic mine (Unger et al. 2003) and Landcare Funding to remediate legacy tailings downstream of the historic Mt. Lyell copper mine in Tasmania (Koehnken 1997).

(3) Research and knowledge sharing improve understanding of common challenges

National and international forums began linking professionals and practitioners with researchers to facilitate knowledge-sharing on a global scale. Several universities and organisations began to focus on mine MR&C during this phase (Table 2)

A further global network formed in response to the closure of multiple uranium mines and mills. This renewed focus on uranium-specific MR&C was supported by the Uranium Mining Remediation Exchange Group (UMREG) which held its first meetings in the USA and Germany from 1995 (International Atomic Energy Agency 2011) with Australian leadership and participation.

Table 2. Sample of Australian MR&C research initiatives.

University/ Sponsor	Research Group	Date established
University of Queensland (UQ)	Centre for Mined Land Rehabilitation (CMLR)	1993
UQ	Australian Centre for Mining Environmental Research (ACMER)	1998
University of New South Wales	Australian Centre for Sustainable Mining Practices	2009
Curtin University WA	Mine Rehabilitation Group in the School of Environmental Biology	Late 1980s–1990s
Curtin University WA	ARC Centre for Mine Site Restoration (CMSR)	2017
University of WA	Australian Centre for Geomechanics (ACG)	1992
University of WA	Mine Closure Conferences (ACG with partners)	2006 – annual conferences commenced
Australian Coal Association Research Program (ACARP)	1992 commenced funding for safety and production research initially	1997 MR&C research began
University of Tasmania	Australian Research Council – Transforming the mining value chain (geochemistry of wastes)	2015
Charles Darwin University, NT	Environmental Science Learning and Teaching – restoration ecology	2002
University of Newcastle, NSW (previously based at University of South Australia)	CRC CARE moved to Newcastle to expand into mine R&C	2015 (since 2019 in collaboration with TFI for Mine Rehab conferences)

The Australian government further supported knowledge sharing by producing a series of Best Practice Environmental Management in Mining booklets (BPEM) (Needham 1999) engaging industry, government, consulting and research professionals in the writing process. At this time one booklet dealt with revegetation and rehabilitation but none dealt specifically with mine closure and completion (Environment Protection Agency 1995).

(4) Attention to benefit distribution and, long-term consequences including mining legacies

Community and government discontent about the balance of benefits and costs of mining focussed on a number of issues. One concern related to profits from finite resources moving offshore and led to reviews and eventual tax reform (McLaren and Passant 2015). As well, the broader issue of managing Australia's short term windfalls from resource extraction for long-term gain (Cleary 2011) drew attention to the long term consequences. With growing global attention to long-term consequences and mining legacies, initially, NGOs paid more attention to MR&C than either governments or industry in Australia. The first mining-related NGO lobby group in Australia, the Mineral Policy Institute, formed in the late 1990s to raise awareness of mining legacy risks. Elsewhere, the Canadian National Orphaned/Abandoned Mine Initiative (NOAMI), multi-stakeholder working group, addressed key challenges of mining legacies by informing policy and practice.

The Australian Tax Review (Australian Government 2010) recommended ways to broaden the tax base and make the tax system more equitable, one form of which was an economic land rent tax based on super profits such as generated during mining booms (McLaren 2014). By replacing state mining royalties with a national land rent tax on profits (for all land) a more equitable tax could be created, especially during

mining booms. The mining boom in the early years of the twenty-first century negatively impacted other industries including manufacturing and tourism. The community and governments were also concerned about the profits from finite resources moving offshore with insufficient national benefit from the wealth or long term planning for Australians (McLaren and Passant 2015). Problems with implementation led to the politically contentious proposal being modified to a Mineral Resources Rent Tax (MRRT). This modified rent tax was repealed in 2014 (O'Callaghan and Graetz 2017; McLaren and Passant 2015). The very public dialogue between industry and government surrounding these tax reforms heightened society's awareness of mining and the need for Australia to manage the short term returns from it sustainably, for the long-term (Cleary 2011, 57).

(5) Systematising environmental management

Growing awareness of increasing environmental complexity, plus the need to comply with regulations for immediate operational risks and alongside long term environmental risks, resulted in conflicting attempts to systematise environmental management. One example is the International Organisation for Standardisation's Environmental Management System EMS (ISO 14001) (SAI Global Limited 2016) that documents procedures to ensure repeatability, efficiency and standardisation. The mining industry in Australia was an early adopter of EMS (ISO 14001 adds up 2006). This was encouraged by governments in Australia, such as Queensland, where a discount on rehabilitation financial assurance was offered to those companies that were ISO 14001 accredited. However, ISO 14001 did not encourage the integrated and holistic systems view that would have translated the ESD rhetoric into practice (Lavery 2011). Instead, the systemising of environmental management, embraced by both companies and regulators, caused a burgeoning of paperwork.

Summary

During Phase 2, Australian practitioners incorporated additional forms of MR&C knowledge, especially geochemistry, ecology and the social sciences. This demonstrated recognition that mining impacts extended beyond soil stabilisation and onsite vegetation to impact downstream catchments, land uses and communities beyond the mine. International initiatives and growing awareness of environmental consequences resulted in Australian policy and practice on ESD. Practitioners began to embrace the triple bottom line rhetoric and a broader understanding of the environment as connected with social and economic factors outside the spatio-temporal boundaries of mines. One notable consequence was the development of a series of booklets on best-practice environmental management in mining coordinated and published by the Australian government's Environment Protection Agency. In addition, states took action, for example, MR&C in New South Wales adopted a regional planning focus to address biodiversity goals by connecting wildlife corridors across the Hunter Valley mining region. However, bureaucratic approaches, and compliance focussed EMS did not lead to improved MR&C for the sector. Local improvements in MR&C occurred in some instances driven by professionals and networks of knowledge in mining regions. Attention to rehabilitation was not accompanied by a focus on closure as a holistic task that involved reconciling large mine voids and waste heaps and stakeholders expectations about sustainable post-mining

land uses. Hence, MR&C knowledge-building and practice was unable to keep pace with the growing mining footprint and the associated technical challenges of large constructed landforms, including final voids.

Phase 3: 2005 to the present (2019) – liabilities and residual risk, 'pass the parcel'

Since 2005, MR&C is not a priority during up-cycles in commodity demand caused by a rush to commence or expand mines. However, there is public unease as external stakeholders' awareness of mining's legacy liabilities grows. Companies are increasingly challenged about MR&C outcomes in their quest for community support and approval for mining, or gaining social licence to mine (Bainton and Holcombe 2018b). This social licence represents the level of acceptance or approval by non-contractual stakeholders (Browne, Stehlik, and Buckley 2011) who can, in often informal yet powerful ways, block or delay projects if they are not convinced of their merits. Similarly, community and NGO stakeholders have questioned government legitimacy and effectiveness as a regulator of the sector (Roche and Judd 2016; Environment Victoria 2014). Stakeholders themselves now seek greater involvement and influence with a rising expectation of a net-positive legacy from mining, whereas mining companies try to offload risk. In the last few years, governments are paying attention to MR&C in regions where multiple mine closures are anticipated and international bodies are giving attention to critical risky features in particular tailings storage facilities, in response to failures and inquiries. Four trends evident during Phase 3 are described below.

(1) Preaching of leading practice is not matched in performance

International, national, industry and government guides produced in this phase demonstrate that although a quantum of critical knowledge exists, it is not embedded in practice in Australia. For instance, the Australian government's updated series of *Leading practice: sustainable development in mining* includes separate booklets profiling the process of mine closure as distinct from mine rehabilitation (Australian Government 2016a, 2016b). Closure includes environmental rehabilitation but is broader as it encompasses socio-economic aspects of mine completion. However, the leading practices outlined are not yet widespread. In another example, impact assessment processes in Australia are dated (circa 1970) and 'are due for overhaul' (Ross and Carter 2012) but the main subsequent change is a backward step in devolution of environmental approval powers to the states from the Australia government (McGrath 2014). Further, the Australian mine closure strategic framework developed in 2000 (ANZMEC and MCA) has not been updated to keep pace with changing stakeholder expectations. However, reference is made to the need for early closure planning, life of mine rehabilitation and legacy site management, in the recent Resources 2030 Taskforce report on Australian resources as the government seeks to grow the Australian mining sector by ensuring it is globally competitive (Australian Government 2018b). In order to improve the sector's environmental performance there are recommendations for nationally consistent approaches for MR&C (Australian Government 2018b, 63). However, Southalan's (2019) review of this report and other regulatory documents observes that Australian regulation lags

behind best contemporary practice because of the limited reference to, and use of, relevant international guidance and reports.

Regulatory guidance and capacity-building activities have not yet caught up with professional needs. Rather, support for stakeholders to understand and address the challenges of mine closure comes from the following alternative sources:

- industry peak bodies (e.g. the ICMM integrated mine closure toolkit 2008, updated in 2019), and their collaboration such as the 2019 Global Tailings Review (ICMM, UN Environment, and Principles for Responsible Investment),
- larger companies that are sharing knowledge more widely to improve the capacity, performance of the whole industry (e.g. Anglo American's SEAT Closure Toolbox), and
- professional bodies like Australian National Committee on Large Dams that produce guidelines that include closure of tailings dams (ANCOLD 2019); and AusIMM through its Sustainability Committee (Keogh 2009) which became the Community and Environment Society in 2013 (C&E Society 2014) and through publications (e.g. 'From Start to Finish') (McCullough et al. 2018), and
- academic conferences (e.g. 'Mine Closure', Australian Centre for Geomechanics, University of WA; 'Life of Mine', Centre for Mined Land Rehabilitation, University of Queensland with AusIMM; 'Mine Rehab', Tom Farrell Institute, University of Newcastle) (see Tables 1 and 2 for dates and details).

(2) Avoiding the risks associated with closure, rehabilitation and relinquishment

One method mining companies use to avoid tackling financial, social and environmental risks at the end of mine life is to sell the mine. As mines become depleted or unprofitable, a common strategy is for larger multi-national mining corporations to sell them to lower-capitalised, smaller mining companies often at a greatly discounted price. For example Rio Tinto sold Blair Athol coal mine for $1 to the smaller company TerraCom; and a similar transfer occurred for Isaac Plains coal mine in Queensland (Roche and Judd 2016). Another example is the transfer of ownership of mature assets to Indigenous communities. While hailed as a success for companies and Indigenous communities, the MR&C liabilities of these operations are rarely discussed (Topf 2017).

A reason smaller mining companies and Indigenous communities agree to this arrangement is the prospect of deriving economic value in waste by exploring the principles of the circular economy for mining wastes (Mudd 2013; Memary et al. 2012; Lèbre, Corder, and Golev 2017). For example the Chinese owned company, MMG sold Century Zinc mine to New Century Resources; and, Mount Morgan mine was sold by explorer, Perilya, which sold it to Norton Goldfields which engaged with mine operator Carbine Resources to investigate residual metal values in wastes (Lèbre, Corder, and Golev 2017). Community and NGO organisations, however, interpret these transfers as liability shifting processes. Therefore, the practice is colloquially referred to as 'pass the parcel'. Governments favour this option as it limits job losses (Watson and Olalde 2019) and at a local level, communities hope the practice unlocks extended prosperity through employment and demand for local businesses (Terzon 2018). However, if the last link in the ownership chain does not successfully close the mine, the benefits are undermined and the negative impacts only temporarily deferred (Watson and Olalde 2019).

A further practice employed by mining majors is to simply cease production and classify a mine as under *care and maintenance*. While this is not a legal term, it is used by industry to describe a hiatus in production. It differs from 'closure' as it involves temporary cessation of operations not permanent closure, and therefore does not require demonstration of progress towards satisfaction of completion criteria (Department of Premier and Cabinet et al. 2017; Queensland Government 2018a). The danger of this approach is that mines can exist in a state of *care and maintenance* for years, if not decades, creating environmental, social and economic harm.

(3) Regulatory attention to closure risks and legacy liabilities

Research indicates more mines close prematurely (75%) than reach the planned end of mine life (Laurence 2006) and many closed mines have an unforeseen requirement to manage aspects like water, in perpetuity (Byrne 2013). There is growing awareness by governments that regulations that address mine *rehabilitation* do not adequately address *closure*, and the long-term management of risks that remain after closure.

The myth that mines require only limited monitoring and maintenance after closure is implied in most tools used by industry and regulators for calculating rehabilitation costs (Department of Environment and Heritage Protection 2017; New South Wales Audit Office 2017). Moreover, compliance-focused companies know that closure plans are not yet required in all Australian jurisdictions with most referring only to *rehabilitation* or *rehabilitation plans* (New South Wales Government 2013; Department of Environment and Heritage Protection 2014; Government of Victoria 2017). When closure plans are required, it is common for them to grossly underestimate closure costs (Sheldon, Strongman, and Weber-Fahr 2002). Regulators in some, but not all, Australian jurisdictions are beginning to recognise these risks. These regulators have begun reviews and reforms in: progressive rehabilitation, closure planning, assessment of risk, calculation of residual risk (the risks that remain after all of the MR&C work has been completed (Queensland Government 2018b)), and financial provisioning for closure. *Closure* is now included in Queensland legislation that requires a 'Progressive rehabilitation and closure plan' (Queensland Government 2018c).

In addition to the challenges of preventing legacy liabilities and funding existing liability, is the question of what to do about abandoned mines in the context of contaminated land legislation. At present, high environmental risk legacy mine sites are not placed on contaminated land registers (New South Wales Audit Office 2012, 2014). This means that these mines are not accounted for as a liability despite, or because of, this liability being larger than accounted contamination. While 'Polluter Pays' legislation (Joseph 2014) is common in Europe (European Commission 2019), the USA under the *Comprehensive Environmental Response, Compensation, and Liability Act* 1980 (CERCLA or Superfund) (United States EPA 2019) and Canada, it is not widely applied to mine wastes in Australia (Preston 2009; OECD 1992).

Legacy liabilities also extend to surrounding environments and towns. For example, in north Western Australia, mining of asbestos ceased more than fifty years ago, yet residents of the town of Wittenoom were encouraged to leave because of the prevalence of health harming asbestos in their town (De Klerk et al. 2013). Nevertheless, some residents remain and tourists continue to be drawn to the natural beauty of the gorges. Rather

than have those responsible for the contamination clean up the township, authorities formally de-gazetted Wittenoom township in 2007 (Michelmore 2019). This did not compensate traditional land owner concerns for residual impacts such as the subsequent death of family members who had worked for the mining company or deprivation of access to their traditional land (Melville 2019).

(4) More diverse stakeholders become active on MR&C

During Phase 3, a greater number of community and NGO groups, as distinct from industry and government, have become active about MR&C. The low-value sales of spent mines, increasing numbers of abandoned mines, and mining impacts outstripping MR&C progress have alarmed numerous groups and organisations. They challenge poor MR&C performance in every way possible and include:

- Australian Conservation Foundation,
- Lock the Gate,
- Environmental Defenders Office,
- The Australia Institute,
- T J Ryan Institute,
- Royal Society of Queensland,
- Sunrise Project and
- Mineral Policy Institute.

Climate change concerns, and changes in international demand for coal affect commodity prices, confounding the risks perceived by these groups and drawing attention specifically to coal sector MR&C. One way in which the sector has responded is by establishing the Upper Hunter Mining Dialogue initiated by the NSW mining industry in 2011 (Upper Hunter Mining Dialogue 2018). This forum is made up of over 70 stakeholder groups, including Landcare. Because of a growing list of ageing mine assets, communities and NGOs are also demanding the Australian government undertake more coordination which has resulted in a series of inquiries by the Australian Senate (Parliament of Australia 2017; Environment and Communications References Committee 2019) and the Council of Australian Governments (COAG) (Government of Western Australia 2017).

Landcare is an enduring example of action by community stakeholders on NRM issues related to MR&C. It is referred to as an 'ethic, movement and model' founded on stewardship and volunteers (Robins 2018, 385) and has played a pivotal role in facilitating knowledge sharing and applied action as a model for community-based natural resource management (Curtis et al. 2014). Unfortunately, during this period, Landcare was subsumed into the *Caring for our country* program. This program undermined the regional model for NRM by centralising government control, prioritising measurable outcomes and adopting market-based delivery mechanisms to ensure immediate value was realised from public investments in NRM (Robins and Kanowski 2011; Tennent and Lockie 2013)

Regional communities, some of which have active environmental and Indigenous groups, have entered the fray. They are concerned about economic futures and favour using former mine sites for novel ecosystems and economic systems, including new industries, rather than having ex-mine sites permanently 'sterilised' or dormant, particularly

where compatible land uses are possible in buffer lands (Muswellbrook Shire Council 2017). The National Heritage listing of the city of Broken Hill and its mine (Australian Heritage Council 2015; Altenburg, Crocket, and Pearson 2016) challenges the assumption that rehabilitation should remove evidence of mining and establish vegetation as the main goal. Instead a sustained future use in cultural heritage tourism is possible (New South Wales Government 2013). Communities are also concerned about a social vacuum that could develop if the loss of a major source of employment results in a population exodus (Bainton and Holcombe 2018a). NGOs have, however, drawn attention to the employment opportunities possible if governments embark on abandoned mine rehabilitation (Lock the Gate 2016).

Academic organisations are another group in civil society that have been influential. They facilitate an 'evidence-based' approach to knowledge sharing and catalysing change. For instance, the Tom Farrell institute (University of Newcastle, NSW) has hosted nine annual mine rehabilitation conferences, most recently in conjunction with the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) (Figure 1). Some environmental researchers have worked with environmental practitioners to develop clearer standards for ecological restoration. For example, the Society for Ecological Restoration Australasia's (SERA) standards are voluntary and apply to all forms of ecological restoration, including mining (Society for Ecological Restoration Australasia 2017).

Summary

The current phase shows that implementation lags behind knowledge. There has been limited follow-up on global initiatives on biodiversity and mining legacy by Australian operators and regulators. The concept of sustainability is increasingly challenged by the existence of large inventories of abandoned/legacy mines and by community awareness of the liabilities of un-economic, unsatisfactorily rehabilitated mined lands. Community groups are increasingly voicing concern about the rate of progress on, and quality of, MR&C and are demanding greater accountability from both the mining sector and government.

Discussion: emerging lessons for Australia

This article reviews shifting priorities for, and stakeholders involved in, MR&C over the last 40 years in Australia. It is clear that communities, NGOs, and professionals, as well as governments, have been integral to transitioning Australian MR&C from an environmental focus on soils, landforms and vegetation cover within mining leases in Phase 1, to the recognition that impacts extend beyond the boundaries, particularly for water and biodiversity in Phase 2. This occurred at a time when global ESD initiatives influenced Australian government ESD policies that flowed on to state and territory governments. It is during the contemporary Phase 3, that the concept of *closure* as more than *rehabilitation*, is being realised. Previously overlooked, but challenging, environmental features like voids are now included in the closure discourse. Governments' dominant role in determining the nature and progress on MR&C, is now challenged, as other stakeholders seek to be involved. With far greater involvement of communities and NGOs during Phase 3, there are expectations that MR&C address longer time-frames of planning and management,

beyond cessation of mining as an additional regulatory phase that was previously neglected. The review points to potential for future developments.

Directions for the future

An optimistic trajectory would see national minimum MR&C standards that address in-perpetuity management, and legislation to address regulatory black holes, including legacy site management by governments. MR&C would ensure socio-economic value creation integrated with environmental rehabilitation as progressive closure with social transition (Post-Mining Alliance 2007; Post-Mining Alliance, IUCN, and ICMM 2008; Bainton and Holcombe 2018a; ICMM 2019). This trajectory would feature cross-functional integration, 'systems thinking', and multidisciplinary and interdisciplinary research (Lavery 2011). Regular and effective two-way stakeholder engagement throughout the mining life cycle would become routine, not just for mining approvals and not left until too late in the mine's life to influence outcomes (Browne, Stehlik, and Buckley 2011). Importantly, Indigenous rights and interests would be more central to MR&C instead of being largely invisible (O'Faircheallaigh 2013; Smith 2018; Northern Territory Department of Mines and Energy 2013).

An optimistic trajectory would also be more sensitive to context and include more local knowledge. In this respect, local government would have greater input on mine approvals to ensure MR&C meets local government and community needs to help overcome the often-neglected socio-economic dimension of closure planning. For example, collaboratively designed and planned use of buffer land has the potential to maximise beneficial outcomes, as with the Landcare model of grass-roots engagement with local knowledge. Context sensitivity, following leading principles of engaging stakeholders throughout a mine's life is as important as progressive rehabilitation of land (Whitbread-Abrutat, Kendle, and Coppin 2013). Regional planning frameworks could integrate multiple dimensions of mining activities and associated MR&C, providing a platform for dialogue and conflict resolution in all mining regions. Involvement of diverse yet relevant expertise from agencies and disciplines currently under-represented in MR&C, would allow for greater innovation in a range of areas (e.g. cultural heritage, tourism, regional development, infrastructure, planning). Demonstration sites of mine transformation to beneficial post-mining land uses (both legacy and contemporary) could create focal points for knowledge sharing and learning. These changes will require a more widespread proactive 'beyond compliance' approach for MR&C by industry (Stevens and Dixon 2017).

If Australia does not alter the way the mining sector addresses MR&C, a more pessimistic trajectory would be most likely. The *status quo* would continue with a reactive, minimalist, compliance focus by industry. This lack of initiative and multi-stakeholder engagement would restrict MR&C improvements needed for successful closure and relinquishment. Without proactive leadership from industry on MR&C, government would be forced to impose what industry may consider cumbersome legislative requirements, conduct audits, and pursue inquiries. Abandoned mines would continue in an ambiguous environment of regulatory black holes and reactive programs where valuable resources are wasted and key stakeholders excluded. Cultural heritage values and other potential socio-economic benefits from regeneration, as more than MR&C, would not be realised under this trajectory. Further unfortunate outcomes are possible such as rehabilitation practices

that remove evidence of mining ignoring heritage conservation for significant sites; leaving mines in un-rehabilitated limbo; or passing an impacted environment either to an ill-equipped future mining company or individual landholders. Without legislative clarity and cross-jurisdictional consistency on critical elements of MR&C, along with cyclical knowledge losses there would be continued creation of legacy liabilities for future generations. The result of knowledge loss would put the mining sector into a repeating loop characterised by restudying what is known without shifting to new and innovative areas of research leaving government in the position of potentially introducing policies that have failed elsewhere.

Conclusion

This study of the Australian mining sector asks the question, 'how have priorities and stakeholders in Australia's mine rehabilitation and closure (MR&C) practice shifted over the last four decades?' From the data presented, we suggest that this has evolved through three phases. The current phase reveals growing public attention to MR&C alongside a plateauing of performance standards. Ineffective regulations and regulatory silos, artificially separate elements of MR&C that are interrelated, thereby generating gaps and ambiguity. By drawing attention to turning points, advances and regressions in MR&C priorities we have highlighted promising avenues for improved management of MR&C in Australia and internationally.

At present, Australia is facing an uneven future for MR&C, not unlike periods in the past. There are some companies, jurisdictions and regions showing leadership and serving as models for others to learn from, but there is no consistent shift toward improved understandings and practices across Australia. If their lead is followed and lessons are learned, there is potential for a fourth phase of MR&C to emerge that is characterised by: coordinated action from multiple stakeholders, regeneration of socio-economic value, long-term planning horizons, low residual risks, cross-disciplinary understanding and integrated regulatory processes. With these supports in place, it would be possible to create opportunities for beneficial processes and sustainable post-mining uses facilitating a smoother transition to post-closure.

Acknowledgements

This article builds on data gathered for an Australian Senate Inquiry submission (Unger 2017). The authors would like to thank the anonymous reviewers who gave valuable feedback on earlier drafts which enabled us to improve the article.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The first author is the recipient of a Coal Minesite Rehabilitation Trust Fund post-graduate scholarship from the Queensland Resources Council and Queensland Government.

ORCID

Corinne J. Unger http://orcid.org/0000-0002-1982-6967
Jo-Anne Everingham http://orcid.org/0000-0001-7631-9462
Carol J. Bond http://orcid.org/0000-0003-2919-2790

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