Proceedings of the 25th Annual British Columbia Mine Reclamation Symposium in Campbell River, BC, 2001.
The Technical and Research Committee on Reclamation

PLANNING FOR CLOSURE IN THE POST-INDUSTRIAL AGE: A PROPOSED FRAMEWORK FOR BUILDING MORE SUSTAINABLE MINING COMMUNITIES.

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ABSTRACT

The focus of mine closure policies and practice in British Columbia has undergone considerable change since the first closure laws were enacted in the late 1960s. Even though the technical standards for determining a successful mine reclamation project have risen considerably over the past three decades, the public's growing hostility toward the industry suggests that expectations have risen even faster. With terms such as "ecological footprint", "carrying capacity", and "sustainability" becoming part of the language of everyday discourse, the mining industry is under enormous pressure to demonstrate that mine closure and reclamation practices are consistent with the public's increasingly sophisticated understanding of what constitutes sustainable development.

In response the mining industry has begun to integrate sustainability principles into their operational and closure planning, but developing a framework for measuring actual system performance remains elusive. Sustainable Development Indicators (SDIs) provide a tool for identifying and measuring progress toward sustainability but a problem with many of the commonly used indicators is that they were developed by experts for experts and as a result fail to resonate with the public. With a more pluralistic, inclusive selection process SDIs have the potential to significantly alter the public's perception that mining is antithetical to the concept of sustainability. The authors conclude by proposing a framework for creating indicators of reclaimed areas that utilizes a heuristic model to integrate technical and ecological data with local knowledge. This model would assist reclamation planners in determining which indicators are critical in shaping the opinions of the different stakeholder groups.

INTRODUCTION

> *The success of the mining industry of the twenty-first century begins with its relationship with the public.*
>
> (National Mining Association, 1998)

Though often dismissed as a relic of the old economy (MacDonald 2000), the fact remains that the economies of the world still depend heavily upon access to mineral resources (Mining Association of BC 2000). This unceasing appetite for the planet's finite mineral resources will have enormous economic, social, and environmental consequences for countries, like Canada, that are endowed with vast mineral wealth.

As the third-largest producer of non-petroleum minerals in Canada (Mining Association of BC 2000), the citizens of British Columbia have enjoyed many of the economic benefits that are derived from mining. But instead of equating mining with the creation of tens of thousands of well-paying jobs and the source of substantial tax revenues, mining is increasingly viewed as a pariah industry that is the source of significant air and water pollution, habitat destruction, degradation of visual resources, and the disruption of the social and economic harmony of local communities (MacDonald 2000; Roberts et al. 2000). Whether or not these ideas are grounded in reality, the fact remains that public hostility makes it increasingly difficult for the industry to successfully carry out its core business activities in BC.

The need to accommodate public opinion is a relatively recent event in the history of EC's mining industry. At one time miners, with the tacit support of the government, were given what amounted to carte blanche authority over how they carried out their operations. But as a result of changes in social and political behaviour arising out of the Social Justice Movement of the 1960s and the Environmental Movement of the 1970s, governments have been pressured by voters to exercise greater control over mining through increased regulation. This pressure was the catalyst for reforms that led to the enactment of the first reclamation laws 1969 (Britton 1998). From that beginning mining has become one of the most heavily regulated industries in the province with some five Federal and another twelve Provincial laws and regulations covering every aspect of the mining process (Mining Association of British Columbia, 2000). If this trend continues the cost of compliance has the potential to effectively close the province to new mining ventures.

This push for increased regulation becomes even more likely given the growing popularity of the concept known as *sustainable development* (WCED 1987). For an industry that deals exclusively with the extraction and processing of non-renewable resources, at first glance there appears to be an obvious contradiction between the general goals of sustainable development and mining. In attempting to establish that the industry contributes to sustainability, miners (and to a lesser extent government) have argued that through the application of sound reclamation practices mining should be seen as a *temporary use of the land.* Unfortunately making the case to the public that reclamation can effectively restore a degraded site's ecological function and structure is difficult. By any standard reclamation is a highly complex, technical process that takes place within a very broad spatial and temporal domain. These qualities make it difficult to demonstrate to a sceptical public that actions taken today will provide lasting benefits decades or even centuries into the future.

CLOSURE PLANNING IN THE POST-INDUSTRIAL AGE

How then should government regulators and the industry respond to the challenge of sustainability? First of all decision-makers must accept that the rules of the game have changed. As *progress* has been replaced by *sustainability* as the goal of society, so to has top-down decision-making been replaced by a system that gives local people more of a say in decisions that affect their quality of life (see **Table 1**).

Table 1: Shifting Paradigms in Western Thought (adapted from Thering and Doble 2000)

Era/Paradigm	Science	Worldview	Values & Goals	Behaviors
Medieval	Great Chain of Being	Feudal Order	Salvation	Church Elite-directed
Renaissance	Humanism	Monarchy/Colonial Subjugation	Revelation	State & Church Elite-directed
Enlightenment	Mechanical Control	Reformation	Emancipation	State & Merchant Elite-directed
Industrial	Resources	Global Order	Progress	Technocracy Elite-directed
Post-Industrial	Ecology/Complexity	Webs & Networks	Sustainability	Participatory Elite-directing

The requirement to open up decision-making to include all of the relevant stakeholders is becoming increasingly accepted by the industry's leading corporations (Sweeting and Clark 2000). So important is the need to build strong and last relationships with the communities in which the industry operates that David Humphreys, chief economist of *Rio Tinto,* noted in 1996 that the fundamentals of future success for mining companies "will be their ability to align the interests of local communities with their own in areas where they wish to operate and to develop mines within those communities on the basis of mature and respectful partnerships." (Humphreys quoted in Epps 1997, p 33). Though Humphreys was addressing the issue of mine development in the developing world, his conclusions are just as relevant for a country like Canada where community opposition led to the cancellation of plans to develop world class mineral deposits at Windy Craggy and in the Taku River Region of Northwestern BC (Gillis 2000).

Looking specifically at how the post-industrial paradigm should affect closure planning, one would expect to find in place a system that invites public participation starting with the initial closure design and concluding with the final closure plan. While some constructive steps have been taken in this direction[1], the existing regulations lack provisions for direct public involvement in closure planning (BCMEI 1997).

INDICATORS OF SUSTAINABILITY

As it now stands closure planning is an elite-directed activity focused on highly technical physical, chemical, environmental criteria (BCMEI 1997; Ricks 1997). So what can be done to "democratize" the closure planning process? Even if an acceptable mechanism was found to bring together all of the stakeholders, communication between the "experts" and those representing the communities would be difficult. What is required is a device that can break down these barriers to open communication. We suggest that decision-makers look to the use of sustainable development indicators (SDIs). On the surface the idea of using indicators to explain complex information is not a novel idea. Already there are number of industry sponsored SDI initiatives[2] under way (Carbon 2000). In general they tend to rely on a relatively small number of indicators to communicate results in the same way as GNP is used to measure economic progress (Placer Dome 1999; BHP 2000). While we believe that this is a step in the right direction, we also believe that the top down, expert driven process used by the industry to identify appropriate performance indicators is flawed. In creating a process designed by experts for experts, the resulting indicator sets tend to be highly technical in nature and this limits their value as a vehicle for engaging public input and support. We believe that a better way for selecting SDIs is one that would effectively integrate expert opinion with input from the local community. Ideally this merging of scientific and local knowledge would produce a set of indicators that would be both readily understood by members of the community (e.g., does a local stream continue to support salmon runs), while at the same time meeting the broad technical and legal requirements of the provincial regulations on mine reclamation.

In the course of sketching out the broad outline of how our alternative process would work, we determined that the biggest difficulty lay in finding a way to integrate, within a coherent structure, each stakeholder group's differing perceptions of what a reclamation project is intended to achieve. Depending on the knowledge and experience that they bring to the table, each group may have a very different

[1] To date there has been three attempts by government (Equity Silver, Brenda and Sullivan Mine), and one by industry (Island Copper) to broaden the scope of public input on decisions pertaining to closure.
[2] An important deliverable of the Global Mining Initiative is a set of SDIs.

understanding of the project's intended goal and objectives (Fig. 1). These differences would also affect decisions on which indicators provide the most useful information on human and ecosystem wellbeing.

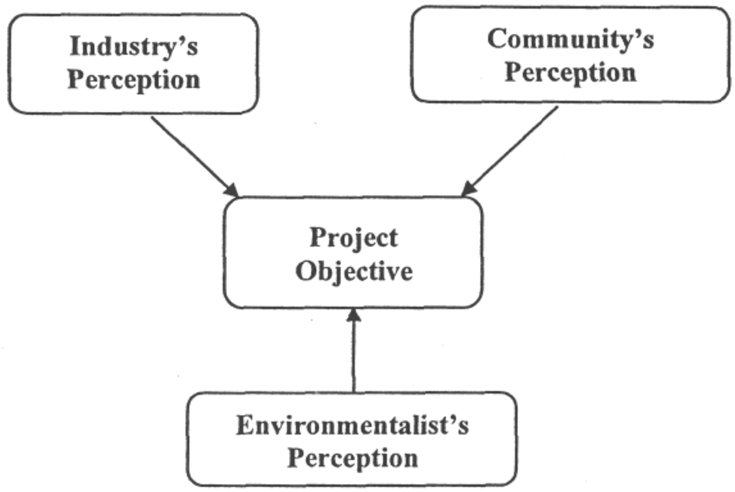

Fig. 1. Multiple views on a project's goal (adapted from Bell and Morse 1999)

We concluded that if it were possible to quantify these perceptual differences it would be much easier to identify indicators that would satisfy the needs of all stakeholders. For instance, reclamation experts may argue that the goal of the project should be to establish certain pioneer species of trees whereas the community may be much more interested in trees that have direct commercial value. How important is this difference? Will it be a major source of conflict that divides the mine owners and the community? To answer these questions we determined that a need existed for a system that would describe, analyze and eventually deal with the paradoxical and chaotic dynamics of social systems.

HEURISTIC MODEL

A properly designed heuristic model could satisfy these requirements, quantifying the differences in perceptions and allowing us to create an index for ranking the "success" of reclamation activities. Heuristic models have the ability to accurately simulate how humans perceive the evolution of an idea from one of complete acceptance to total rejection. In the context of this project, the model will use a Weighted-Inference Method (Meech and Veiga, 1997) to combine information on social, biophysical and economic indicators to determine each stakeholder group's degree of belief that mining can be made more sustainable through reclamation. This Weighted-Inference Method is adapted from the basic neural equation which propagates weighted evidence to a conclusion and is implemented within a heuristic model. The model is based on the Perception approach to neural-computing developed by Rosenblatt (Meech and Kumar, 1993). The Weighted-Inference Method derives a Degree Of Belief ($DoB_{conclusion}$) in a conclusion by multiplying the importance of each piece of evidence (W_i) by the Degree of Belief (DoB_i) that the evidence exists. This summation emerges from a single node (or rule) as a Degree of Belief in a conclusion ($DoB_{conclusion}$) ranging in value from O to 100% (Meech and Veiga, 1998).

$$DoB_{conclusion} = \sum_{i=1}^{n} W_i \cdot DoB_i$$

In most heuristic models, weights for each piece of information (W_i) are established by experts; consequently they often have little meaning to the general public. In our model different stakeholders would be asked to weigh the importance of each indicator defined in the inference model by assigning a value between 0 (not important) and 1 (very important). The value assigned would be dependent on the user's perception of how important a particular indicator is in demonstrating the success of the reclamation effort. For example, an engineer or a company manager may assign more importance to the slope stability of waste dumps than to how the dump might appear when viewed from the highway.

In order to establish that a mine site was successfully reclaimed many indicators should be considered, as exemplified in Table 2. For the sake of simplicity we have identified only two possible stakeholder groups but in reality this list could very well be expanded to include government inspectors, environmentalists, aboriginals, etc. There may even be a requirement to measure perceptual differences based on criteria such as gender, race, or age. The model is inherently flexible allowing for decisions on who to include to be made on a case-by-case basis.

Following the assignment of weighted values to the list of indicators, the Degree of Belief (DoB_i) in each piece of information would then be checked in the field to confirm whether that specific indicator exists or not in a reclaimed site. The DoBs are established based on the subjective possibility that such indicators exist or are based on fuzzy sets for measurable parameters such as pH (Fig. 2). We fully expect that when we field test our system there will be marked differences in the values of $DoB_{conclusion}$ for each of the major stakeholder groups, reflecting the different levels of knowledge and experience that each group possesses.

We believe that our model is equally valuable as a decision aid for evaluating the perceived sustainability of existing reclamation projects and those that are still in the development stage. When used to evaluate new projects, the DoB_i is replaced by the possibility (%) that what is being proposed in the company's reclamation plan is feasible within the limitations imposed by the proposed budget or appropriate according to the site specific situation. For example, reclaiming a site in a remote area of the province for use as a tourist destination would be both costly and an inappropriate use of the land. Because experience has shown that it is much cheaper to reclaim a mine by planning for closure at the earliest possible moment, there is a strong economic incentive to know if the reclamation plan needs to be changed to suit the demands of the community. Even relatively small changes in the proposed reclamation budget may substantially affect the project's overall economic feasibility, so it is important for the .company to know the extent of these costs before it proceeds to the mine development phase.

Table 2: Example of Indicators of a Reclaimed Mine Site and their Importance Ranked by Experts and Community Members.

Indicator of a successful reclaimed site	**Importance**	
	W_i (engineers)	**W_i (community)**
Appearance of the waste dump from the highway	0.50	0.90
Slope stability of the waste dump	0.90	0.70
pH of the drainage	1	0.60
Presence of heavy metals in the drainage	1	0.90
Agricultural use of land after closure	0.50	0.95
Recreational use of land after closure	0.50	0.80
Use of land by wildlife	0.90	0.75
Presence of a grizzly bear in the reclaimed site	0.50	0.90
Type of vegetation in the reclaimed site	0.90	0.60

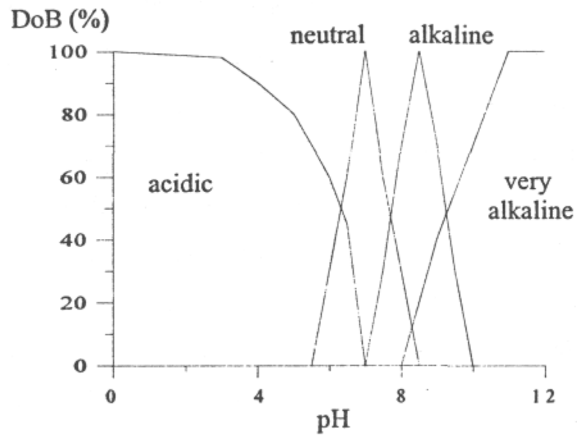

Fig. 2. Fuzzy Sets to describe the pH of the waste dump drainage.

We also envision that by inputting this information into a Geographic Information System (GIS) one would be able to perform complex spatial and temporal analysis of the data. In this way one could determine which of the indicators is *critical* in shaping the opinions of the different stakeholder groups. This will be important in determining what actions should be taken to address the specific points of conflict.

We believe that such a model would offer potential users with an important new tool for identifying areas of potential conflict and cooperation between miners and the communities were they operate. When used by the mining industry our model is intended to function as a decision aid to assist reclamation planners in developing designs that are not only technically sound, but also consistent with the site's unique social and environmental history. Our model is also intended to assist local citizens in their pursuit of designs that reflect their vision of how the site will contribute to the long-term social, environmental and economical health of their community.

The suggestion that a heuristic model could be used to aid the mining industry in the management of complex processes is not unique to the circumstances described in this paper. Expert systems using similar approach have been developed to assist miners in the selection of optimal mine methods (Rossouw 1995), mill management (Prasad & Ramani 1989), and bioaccumulation risk assessment of mercury (Veiga, 1994). What is unique about our model is that offers an approach for developing SDIs differs considerably from that being taken by government (NRCan 1998, Bossel 1999), academics (Warhurst 1998), and the industry itself (Noranda 1999, Placer Dome 1999). All three groups have chosen to focus their efforts on developing indicators that are intended to satisfy the needs of scientists and senior government policy makers.[3] Consequently these indicators are highly technical in nature and are ill suited as a vehicle for communicating to the public the industry's determination to make its operations more sustainable. And because lay people and experts have a tendency to perceive risks and trade-offs differently, by relying on technical indicators alone the industry risks creating a source of conflict between "reclamation experts" and the communities they serve. This may explain why there is a discontinuity between how the industry and the public perceive the effectiveness of current reclamation practices to meet the demands of sustainable development.

CONCLUSION

"You can lead a person to information, but you can't make them understand it." (Meech 2001, p ii). Though this may be true, with the right indicator you can certainly go a long way toward helping them understand. We anticipate that when it is completed our research will influence the public's perception of the sustainability of the mining industry by removing much of the complexity that surrounds closure planning in BC. We also believe that our research will aid in the empowerment of local people by providing them with the tools they need to build more lasting communities that reflect their ideals and values. In developing a heuristic model for reclamation that more fully integrates the legitimate concerns of both the industry and the communities in which it operates, our research will remove one of the major barriers to the continued viability of the mining industry in British Columbia.

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[3] For example NRCAN's list of sustainability indicators will include such items as metal recycling rates, energy consumption rates and greenhouse gas emissions.

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