Innovation in the Design of Sustainable Mining Systems

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ABSTRACT
The global mining industry is being challenged by the need to more effectively implement sustainability principles through new competitive processes that reduce environmental impacts and gain social license.

As a community interested in Intelligent Processing and Manufacturing of Materials, we need to challenge our collective thinking, foster reflection on the true nature of innovation, and devise new strategies to cultivate an environment that is conducive to people from diverse backgrounds learning and thinking together for better participatory design, which lies at the heart of sustainability. Such strategies will be essential for the effective design of future mining projects that successfully gain social license. They require a holistic approach that is critically dependent upon the fair engagement and participation of various communities of interest throughout the project lifecycle.

This paper explores how we can challenge our normal assumptions and endeavor to understand our current patterns of thought and analysis when planning new mining projects, thereby opening new windows of opportunity for creative approaches. Case studies will demonstrate the practical implementation of systems thinking, value networks and other collaborative tools that comprise innovative learning and thinking in mining and other industries.

MOTIVATION
The collaboration for this paper stems from a shared passion for the humanity of mining and the pursuit of a better means of thinking and learning together. In our experiences with investors, NGOs, aboriginal communities, government, mining companies, and educators we have been struck by the overall inadequacies of the existing processes related to sustainable mining development and social responsibility. The current way of thinking has brought us to this point, but we believe it will take us no further in devising viable solutions to sustainability issues. We are deeply committed to a better future for the extractive industries in balance with a sustainable planet.

This paper is based on a long collaboration, a launching pad to open the possibilities for new conversations amongst ourselves, in the industry at large, and beyond our current networks. We are reaching out to a wider audience to participate in the co-creation of a way forward.

We recognize that not all proposed mining projects should come to life. In reality there is a world of entrepreneurial promotion and a range of projects that cannot be responsibly justified. Our challenge today as an industry consists in finding the means to design better sustainable projects by assessing their inherent strengths and weaknesses with respect to a common goal – that of a healthy relationship between all stakeholders and our planet.

We propose a “systems thinking” approach to managing the complexity of sustainability by engaging all parties in more effective participatory processes using systems thinking, based on a combination of social and environmental science, and founded on mutual respect and a shared vision.
INTRODUCTION

“Insanity: doing the same thing over and over again and expecting different results” – Albert Einstein

When addressing a particular problem, scientists find ways to look at the issue from a different angle, perhaps by changing the rules of the game or introducing a new framework which describes the situation differently. Challenging the most basic assumptions is the first step toward a breakthrough, hence the quote by Einstein.

All too often, previous success strategies are being blindly applied in business and organizations simply because they worked in the past, without questioning their applicability or asking if other strategies might be better suited. For instance, in the design stage of new mining projects, the established practice involves analysis: breaking down the complexity by defining individual parts of the project, solving each component separately using subject matter experts, and then assembling the project from the bottom up. The result is generally presented in a series of voluminous reports that are supposed to form a coherent overall picture of an economically, socially, and environmentally viable project.

In 1983, the United Nations established the Brundtland Commission to address “growing concerns about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development”. The 1987 Brundtland Report, titled Our Common Future, defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This is the most widely quoted definition of sustainability.

For the purpose of this paper, the authors look at sustainability from the perspective of “interconnectedness”. Our thinking converged on interconnectedness as a means to describe the fundamental characteristic of sustainability, based on ecology and the undeniable fact that human systems are an integral part of the natural ecosystem. We strongly believe that heightening our collective awareness for interdependence and interconnectedness will enable new thinking and openness to uncover other possibilities for constructive solutions.

CHALLENGES OF MINERAL RESOURCES DEVELOPMENT

The current approach to planning mineral development projects by industry in collaboration with potentially affected communities tends to be as follows.

Early exploration and project development planning often takes place behind closed doors. This is gradually changing with the development of guidelines such as “e3”, Environmental Excellence in Exploration, which encourages consideration and communication about local interests at the earliest opportunity. Traditionally, prospecting has been conducted by junior companies in an air of secrecy and competitiveness, which is diametrically opposed to the climate of openness and transparency that is desired in a consultative process. Fortunately, enlightened management increasingly recognizes that exploration as an early opportunity to build trusting relationships with communities, recognizing the reality of interdependence and the importance of interconnectedness. At this stage, there is a need to negotiate with communities and government appropriate restoration of terrain disturbed by exploration. The handbook “Working Effectively with Aboriginal Peoples” provides diverse business case arguments for early engagement, many of which are equally applicable to any community of interest (COI). Furthermore, the government of British Columbia is promoting a “New Relationship with First Nations and Aboriginal People” founded on respect, recognition, and reconciliation of Aboriginal rights and titles.

Development planning, socio-economic, and environmental baseline and impact assessment work tends to occur in a piece-meal, under-integrated fashion. Input from COIs to design criteria via traditional knowledge discussions is virtually non-existent and is most certainly not embedded in standard practice, nor is it included in a systematic manner in project planning and decisions.

The emphasis on environmental versus technical or social issues varies globally, as does the degree of political influence over decisions. In some cases, NGOs replace governments in providing communities with the capacity to understand what is happening as a new project begins to take shape. Generally, lack of integration and interaction, or connectedness which recognizes interdependence, in assessment procedures applies to global practices. However, it is encouraging to read about new models of cooperation beginning
to occur between social activists and corporations, as reported in a recent article “Co-creating Business’s New Social Compact” by Jeb Brugmann and C.K. Prahalad in the Harvard Business Review. The authors describe a business model of co-creation where BP partnered with three NGOs in India to market a dual-fuel portable stove. The NGOs provided a wide distribution network for the product, thereby allowing BP to price it affordably for the target market. The company sold its stoves profitably and the NGOs gained access to a new revenue stream to fund other projects. The article points to a convergence in which “companies become a key part of NGO’s capacity to deliver value and vice versa.”

In other words, social license acquisition strategies are not presently hard-wired into planning processes; these are largely driven by the corporate bottom line and a focus on meeting regulatory requirements rather than by a need to find a good solution together. Legal versus moral drivers are still at play, and typically do not meet sustainability principles in a systematic fashion that fits clearly with regional plans or land use concepts. Hence, the various processes are poorly interconnected. Project design criteria tend to be driven by cost and technical drivers, partly exacerbated by silo-styled organization of technical teams. Project evaluations continue to be executed almost exclusively on present day value economics, poorly connected to meeting criteria later in the project life. This method fails to highlight the impact of expenditures made later in the project that benefit communities. Figure 1 below illustrates the interactions between stakeholders, particularly with respect to the information flowing from the corporation toward the other parties.

**Mining Project Information Flow**

The above figure is intended to show stronger and weaker links at various stages of the project life cycle. Dashed lines reflect somewhat reactive and weak interactions. The transverse arrows are the main opportunities for community stakeholders to provide input, usually after the corporation has formed its primary technical and financial decisions and mindset. Light dashed lines represent what is typically referred to as consultation, which falls far short of full participation and collaboration, based on shared values and deep mutual understanding. No government linkages are regarded as particularly strong in direction or leadership and are therefore represented by a solid, albeit thin line. This diagram emphasizes the linearity of the process as well as the low level of interconnectedness.

Experience and the adverse reactions of communities and NGOs demonstrate that this discrete, linear, and analytical process lacks fundamental cohesiveness and warrants a new approach. Collaborative approaches
based on systems thinking and interdependence are needed to solve the seemingly intractable problems of today’s world. Sustainability is a very large and complex, interconnected, multi-disciplinary, dynamic problem domain, which is highly sensitive to a myriad of parameters.

Thus, social and environmental sciences must coalesce in a whole system view. Failure to recognize this principle can have dire consequences, as demonstrated by the Tambogrande project in Peru: through an unprecedented referendum, local activists were able to overthrow federal laws and environmental assessment procedures. Complying with government requirements simply revealed insufficient for the corporation involved, who ultimately failed to acquire social license to operate in the community.9

We propose a systemic way of thinking based on synthesis rather than analysis. This paper endeavors to explore how systems thinking can aid in the participatory design process of sustainable mining projects, opening new possibilities for collaborative approaches.

**SUSTAINABILITY AND PARTICIPATIVE DESIGN PROCESS**

A fundamental management challenge is to construct interconnected and interdependent “systems of processes” that reflect the socio-economic, cultural and ecological complexities of mining projects. These systems can only be authentically set up with the input and cooperation of all stakeholders. In turn, sets of values and weightings can only be equitably developed with meaningful communication between all parties. Using this framework, project planners can develop projects that have a good prospect of gaining not only tolerance, but acceptance. We need to use a systematic approach which integrates technical, economic, environmental and social values and performance criteria in comparing these projects, as much as anything, to demonstrate deficiencies in current processes and the corporations that use them.

Robert Gibson comments that we often presume that economical viability is equivalent to overall benefit to all parties10. The global mining industry study titled “Mining, Minerals and Sustainable Development” (MMSD) gave us seven sets of “Questions to Sustainability” (see below) that need to be answered about the complex system of mining activities, business, environmental conservation, and social stability. Gibson also noted that planning processes “seldom look ahead”; we need systems that evaluate the full mine life cycle using criteria beyond a net present value evaluation criterion.

<table>
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<th>MMSD’s Seven Questions to Sustainability11</th>
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<td>1. Are <em>engagement</em> processes in place and working effectively?</td>
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<td>2. Will <em>people</em>'s well being be maintained or improved?</td>
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<td>3. Is the integrity of the <em>environment</em> assured over the long term?</td>
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<td>4. Is the economic viability of the project or operation assured, and will the <em>economy</em> of the community and beyond be better off as a result?</td>
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<td>5. Are <em>traditional and non-market activities</em> in the community and surrounding areas accounted for in a way that is acceptable to the local people?</td>
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<td>6. Are rules, incentives, programs and capacities in place to address project or operational consequences?</td>
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<tr>
<td>7. Does a full <em>synthesis</em> show that the net result will be positive or negative in the long-term, and will there be periodic re-assessments?</td>
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These seven categories have been sub-divided into numerous more specific elemental questions that must be adapted to specific situations, wherever practical using value sets and criteria that have been developed collaboratively.

The MMSD project points to a practical framework that is likely amenable to collaborative project planning and that builds long-term trust and knowledgeable relationships between stakeholders. Furthermore, a systematic process for evaluating such processes and for evolving methodologies for mutually acceptable balanced decisions is viewed as possible.

In effect, shareholders in mining corporations are now being asked to give up a significant portion of their dividends in exchange for the cooperation and consent of the community and/or aboriginal people or nation...
involved. It also seems intuitive that corporations increasingly have little choice but to be cooperative and more sharing in increasingly well informed democratic communities. Further, there is a school of practical thought that sees reputational capital and market share increasing by contributing to local communities beyond the payment of taxes. If nothing else, there is a business case to cooperate reasonably in order to reduce permitting time, which translates into the cost of borrowing money for longer and/or risking erosion of profit due to inflation or falling metal prices.

Referring to the seven sets of questions for sustainability developed by MMSD it is obvious that all COIs need to participate in a shared learning process for any given project to realize maximum benefits. Once the corporation has recognized that the best business case is a mutually beneficial one that depends on COI participation, the emphasis then shifts to the practicalities of communication and capacity building.

This is where we see a need to help to evolve participative design processes for all aspects of design/planning by learning and thinking together. Key to this is learning how to engage optimally, learning from mistakes and pitfalls of communication and conversation.

Most important is establishing that this is a shared responsibility and not something to be left to communications consultants alone. Engineers, scientists, lawyers and community representatives need to acquire new skills of communication and persuasion. Early engagement, in order to begin learning and thinking together, as well as an exchange of skills and perspectives, is essential – a matter of intuitive common sense.

Gibson recommends looking for the most positive outcomes and for integrated solutions, developing both local and global criteria for decision-making, and improving governance. He asserts that “our decision making structures and processes must (...) engage citizens, communities and civil society bodies as well as government bodies and market players” while “respecting complexity and uncertainty”.

**LEARNING BY DOING**

Our industry desperately needs innovative approaches to thinking and learning together. These approaches are not necessarily new in their own right, but they are largely unexplored in the mining and metals sector. Nonetheless, opportunities to walk down this uncharted path are starting to emerge. For instance, the theme of the 2006 annual conference of the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) – “Creating Value with Values” – recognized a new era of creating wealth and well-being in a socially responsible manner. This approach entails that all participants engage in a shared learning process wherein values are exchanged and examined by all with the intent to agree on an acceptable guiding set for project planning. Critical early encounters need to focus on the exchange of culture and stories as a basis for identifying and understanding the diverse needs of communities of interest and of agreeing on values and ways of measuring them. There is also an important psychological trust barrier or gate to go through early on, where expectations about future process need to be agreed to by all involved parties. This is an area that needs to be rehearsed and honed into a new best practice for engagement. The Mining Team (TMT) concept described below seeks to rehearse such interactions in real, yet non-threatening circumstances.

**The Mining Team (TMT)**

A recent experiment initiated at the University of British Columbia, with the participation of a diverse group of international graduate students, has sought to explore fundamentally improved processes for collaborative project planning, free of conventional rules or expectations. Using the principle of back-casting, diverse stakeholders are encouraged to imagine and act out improved ways of interaction in collaborative mine planning, using quasi-real simulations or role-plays. In effect, the stakeholders are invited to rehearse roles for a collaborative mine planning team that combines technical and regular community folk. The wisdom of diverse perspectives is inter-twined with conventional technical and economic planning and evaluation.

Another innovation being tested by TMT involved video recording, of such simulated interaction and explorations of idealized new planning processes, providing a feedback loop to participants. Poor or weak interactions can be objectively discussed against a framework of mutually agreed values, developed collaboratively by all parties in a series of conversations. Good examples of innovation in planning and related interactions or conversations can also be recorded and shared with other audiences. This method
provides immediate graphic feedback to participants, but also can be used in subsequent collaborative learning events with different industry, community project components.

It is hoped that this technique will evolve as more mining corporations become prepared to enter into open trusting relationships with their communities. Equally, it is hoped that a more systematic and holistic or integrated methodology will evolve to facilitate balanced decisions and trade-offs between short-term profit and longer term improved levels of sustainability. TMT was an early attempt at developing and testing a participative design process for sustainable mining projects. This experience of thinking and learning together led us to the following recommendations:

- Adopt systematic integration of engineering planning, socio-economic and environmental impact assessment, and early engagement; this includes complex scheduling of the flow of information and of decision making milestones and of sophisticated simulations of the interactions between all involved and affected groups of people, such as value networks.
- Develop modern virtual platforms for knowledge sharing that are maintained from cradle to grave.
- Develop improved practice for early engagement with all communities of interest, recognizing inter-dependence.
- Emphasize in mining professional practice a new culture of awareness of the complexity and interconnectedness between the environmental and social sciences.

**BETTER THINKING AND LEARNING TOGETHER**

Our world has undergone dramatic mutations in the last two hundred years, largely provoked by mankind. The pace of change has rapidly accelerated, due to our ability to drive technological and scientific progress. However, our organizational systems – the way we arrange people to perform complex interdependent tasks – have not adapted to the demands imposed by such progress. Once we figured out the optimal structure required to increase efficiency and throughput, we virtually stopped experimenting with new ways of organizing the workplace. The result is modern businesses, governments, and not-for-profits that mimic patterns of organization and behaviours reminiscent of the industrial revolution and command-and-control structures moulded after the military.

Organizations are made of people and, as such, are complex living systems. The advent of the internet and its rapid development have allowed new patterns of task organization to emerge organically, unconstrained by artificial structure and authority. Self-organization in cyberspace – the only free society on earth – is relentlessly dismantling the established norm and proving that co-creation by invitation and mass collaboration on the internet (commonly referred to as Web 2.0) maximizes connectedness and generates value and wealth. The successful outcome of this new paradigm of self-organization and interdependence is possible because of the trust and openness underlying every interaction.

Indeed, better learning and thinking together can occur in the “real world” as well, if we are willing to fundamentally question our assumptions and open up to a genuine dialogue with others. The realization that our society can exist and thrive in a different paradigm may be the single most important discovery mankind will make in this century.

**Systems Thinking**

W. Edwards Deming clearly stated that “new knowledge comes from outside the system”. A system cannot fully understand itself and its transformation requires an outside view. As “mining people” we are looking outside of our system for novel approaches. We are tapping into the discipline of systems thinking and its application in other domains to help us deepen our understanding of sustainability. Systems Thinking is a “world view” (largely based on natural systems science) which seeks to understand the interconnectedness of components as a means to “see the whole”. It is a conceptual framework which promotes synthesis over analysis and brings to light interdependence as the key to unraveling the dynamic complexity of a system.

Analysis has been the mantra of science and engineering for centuries and has allowed for great technological and scientific progress to occur. However, analysis has also created isolated parts, narrow
disciplines (over-specialization), assembly lines, and functional silos. In today’s complex world, synthesis will help us uncover opportunities for profitable and sustainable business practices. In Dr. Russell Ackoff’s words, “analysis produces knowledge; only synthesis brings deep understanding” because synthesis helps us see the whole, rich in interconnectedness.

Deming defined a system as “a network of interdependent components that work together to try to accomplish the aim of the system”. In his book *The New Economics*, Deming illustrates how a System of Profound Knowledge is required to transform our society from “the tyranny of the prevailing style of management” to one of optimization of the whole through cooperation. Many have applied Deming’s teachings to transform their organizations. In this paper, we look at one example in particular which vividly illustrates the potential for applying systems thinking to “dissolve the sustainability mess”.

Case Study: Systems Thinking in Practice at the Yorkshire Brick Company

Alan Winlow, CEO of the Yorkshire Brick Co. (UK) used Deming’s System of Profound Knowledge to tackle the problem of survival of his company in a time of deep crisis. He applied the four pillars of Deming’s philosophy – appreciation of a system, understanding variation, the theory of knowledge, and psychology – to foster a culture of learning and development for everyone working at Yorkshire, thereby propelling the company and its community into a better future.

When Winlow arrived at Yorkshire in 1973, the enterprise had been quarrying a site for raw materials for over 70 years. Some 30 acres of land were mined out and unreclaimed. Furthermore the site was located in a coal field and the area was surrounded by a ‘mess’ of colliery waste, coal stock piles, and railway sidings. The countryside had been plundered and the air quality was poor due to nearby coking plants.

While backfilling the empty quarries with domestic and commercial waste, Yorkshire discovered that the site was producing landfill gas, a mixture of methane and carbon dioxide that is formed by the biodegrading of the organic fraction of the waste. By 1983, Yorkshire had established a recovery system to collect the landfill gas to be used as a substitute for the natural gas to fire its kilns. The reclamation of the quarry resulted in grasslands, and nearby schools developed projects for students to plant trees. A large area was seeded with willow, a very efficient carbon fixing system. Walking trails were established and the community was encouraged to enjoy the green space. The willow is harvested and burned to produce hot water or electricity for the community. The overall system is effectively carbon neutral.

Winlow was able to introduce the System of Profound Knowledge at Yorkshire because the company faced an imminent crisis, brought about by two factors: a precipitous drop in brick demand and an audit report which indicated that the variation in the dimensions of Yorkshire’s products was considerable and well above industry averages.

The application of systems thinking began through the introduction of Deming’s Plan-Do-Study-Act cycle to describe brick production as a system. Understanding variation allowed Yorkshire to improve the quality of their product. Furthermore, this new knowledge of systems brought a growing realization within the organization that the stakeholders in the business were not only customers, shareholders, and suppliers, but also employees, the community, and the environment.

Winlow began to engage the community through its children, by sponsoring school projects such as the construction of a small charcoal-burning kiln enabling students to experience first hand the whole production system from planting willow trees, to harvesting, stripping, and burning into high-grade drawing charcoal. It is important to note that this initiative was triggered by the school principal taking a personal interest in Winlow’s authentic desire to develop a mutually beneficial project. This clearly illustrates the value of connecting at a meaningful level with the community and allowing its wisdom to influence the outcome.

Building trust in a community that traditionally mistrusted the Yorkshire Brick Company as a polluter, with sole interest in profit, proved to be the greatest challenge faced by Winlow. Partnership with the school changed the attitudes of the citizens, which in turn began to take shared stewardship in the sustainable development of the business, the reclamation of the surrounding grounds and restoration of community relationships. This story demonstrates how systems thinking in practice can alter the way business and community learn, think, and work together to develop a better future for all, based on recognition of their connectedness and interdependence.
Value Network Analysis

In her book *The Future of Knowledge*, Verna Allee defines a value network as “any web of relationships that generates both tangible and intangible value through complex dynamic exchanges between two or more individuals, groups, or organizations.” Viewing a system as a value network is a synthetic approach, very different from traditional process mapping or business analysis because it highlights the intangible as well as the tangible value created through interaction.

Allee defines tangible value as “value that is generated by contractual activities that contribute directly to economic gain” as opposed to intangible value “generated by informal, non-contractual activities that help build business relationships and contribute to operational effectiveness.” We interpret tangible exchanges as flows of information, documents, products, or services that are measurable and/or physical, whereas intangible exchanges are abstract and not easily quantifiable. Intangibles are complex variables, often pertaining to the human domain of emotions and values.

At first, we studied the Yorkshire Brick Co. case study and interviewed Winlow to gain a deeper understanding of the triggers that enabled a transformation to occur in the company as well as in the community. Then, we used Allee’s technique of Value Network Analysis to depict the interactions and gain further insight into the value created by the whole system. The following Figure 2 illustrates a simple value network of the Yorkshire story. Solid line arrows show tangible exchanges, whereas dashed line arrows show intangible flows.

This figure is a partial representation of the story, because it illustrates the exchanges up until the point where the students embraced Winlow’s project by trusting him and sharing their enthusiasm with their parents (the community). As a result of the build-up in the quality of these intangible exchanges, the community learned to trust Winlow as a person with genuine interest in its well being and environment. Trust led to a solution beneficial to the whole system.

**Figure 2 Value Network Analysis of the Yorkshire Case Study**
CONCLUSION

Winlow’s journey is a model of how an open dialogue is possible when people become aware of their interconnectedness to other parts of a system. Exposure to systems thinking theory and practice opened a window of opportunity for the entire community. The intangible exchanges of trust made it possible to see a solution beneficial to the whole.

By writing this paper, our own journey in this collaborative process of thinking and learning together convinced us further of the need to foster more opportunities for a diverse set of resources to engage in a dialogue about mining and sustainability. Hence, we intend to seed and fuel a forum using the power of mass collaboration on a virtual platform known as a “wiki”, an interactive set of web sites that allow users to add, remove, and edit content, in effect a collaborative learning and authoring tool. Education about systems thinking and interconnectedness will constitute the foundation for this experiment which will aim to engage the mining and metals industry in an innovative process of thinking and learning about sustainability.

In the introduction to his recent best-seller book *Wikinomics*, Don Tapscott wrote: “While hierarchies are not vanishing, profound changes in the nature of technology, demographics, and the global economy are giving rise to powerful new models of production based on community, collaboration, and self-organization rather than on hierarchy and control.” This statement supports the principles of social engagement as a sound way to manage risk and to find innovative solutions that are sustainable. Sophisticated processes that manage complexity by understanding interdependencies and enhancing broader more sophisticated communication are likely to result in greater harmony, stronger consensus, and more enduring or sustainable well-being for communities and miners alike.

The first example given by Tapscott in *Wikinomics* is the “Goldcorp Challenge”, a million dollar mine design public competition where the CEO openly shared corporate geological data with the global community over the internet and obtained superior advice that enabled the creation of wealth. We would like to envisage a not-too-distant future where the mining and metals industry will benefit from better thinking and learning together to develop a profitable operating philosophy that is in harmony with sustainability principles.

Improved IT tools for visualization and management of large sets of data and information will become increasingly important in developing our ability to understand the complexity of sustainability through a discovery of its inherent interconnectedness and interdependence. These tools are already available, but remain largely underutilized in our industry. In conjunction with a shifting culture away from over specialization and toward more holistic systems thinking, we believe the mining and materials sector will gain economically and in social responsibility. The first step is to imagine a better future and to clearly articulate a vision that is compelling to all parties involved. We hope to have made progress in this direction.

1 Quote attributed to Albert Einstein (1879-1955).
2 The Brundtland Commission was led by former Norwegian Prime Minister Gro Harlem Brundtland and later adopted the name World Commission on Environment and Development (WCED).
5 Prospector and Developers Association of Canada. Environmental Excellence in Exploration, [www.e3mining.com](http://www.e3mining.com)
6 The handbook is available from Indigenous Corporate Training Inc. [www.ictinc.ca/Programs.htm](http://www.ictinc.ca/Programs.htm)
7 [www.gov.bc.ca/arr/newrelationship/default.html](http://www.gov.bc.ca/arr/newrelationship/default.html)
16 ibid
18 The Yorkshire Brick Company case study was compiled from papers by Alan Winlow as well as a personal conversation between Alan Winlow and Laura Mottola.
22 ibid