Abstract: Precious and base metal mining projects can serve as a stepping-stone in moving the mining industry towards achieving compliance with a scientific-principled definition of global socio-ecological sustainability. Using the Framework for Strategic Sustainable Development to assess the current reality of mine project development has resulted in identifying gaps between current best practices and a desired vision of sustainability constrained by science based principles. These gaps provide opportunities for sustainability driven innovation. Evaluation of mining project phases and their impacts on ecological and social systems using the four Sustainability Principles highlight specific opportunities to create value for social, economic and ecologic systems. Companies choosing to develop mining projects using the Framework for Strategic Sustainable Development can expect to achieve many business benefits, including improved reputation, increased transparency and stakeholder trust. Strengthening these aspects will provide robust support to companies as they manoeuvre to define their role in a sustainable society. This thesis examines how current processes for mining projects can be developed to support a successful transition into a sustainable society.

Keywords: mining, sustainability, strategic sustainable development, human needs, systems thinking
Acknowledgements

This work was carried out at the Department of Mechanical Engineering at Blekinge Institute of Technology in Karlskrona, Sweden, under the supervision of Lic. Eng. Sophie Hallstedt and MSc Anthony Thompson. Their support and input allowed for clarity and affirmation the work we were completing was in the right direction.

We would like to extend a very special thank you to Dr. Joe Herbertson who acted as our external advisor. His contributions and conversations were challenging and incredibly important to the evolution of this thesis. We cannot thank him enough for his time and willingness to connect with us.

We would also like to thank the specialists who contributed to our work through interviews: Bruce Harvey, Bruce McKean, Carmen Turner, Dave Parker, Guy Gilron, Helen Rosenbaum, Jacqueline Medvečka, Jamila Abassi, Jim Rader, John Atherton, Jonathan Samuel, Juliana Rudich Rehfeld, Kariann Aarup, Marcelo Vilela Gato, Nathan Monash, Orlando Lima, Petrônio Hipolito, Philip Bangerter, Sophia Wong and Steve Vellacott. We learned a great deal from you. We hope in return we can contribute to your important work in this industry.

We would like to share our gratitude with our classmates in the Strategic Leadership towards Sustainability Program. Conversations resulting from our peer group presentations, in the hallways, social gatherings and bike riding to and fro, around Karlskrona have stimulated ideas and shown us great support. All of these interactions were immensely useful and proved that some of the best learning occurs outside of the classroom.

Finally we would like to thank our families for their support. None of this would be possible without your belief and willingness to give us the space to go on this learning journey.

Love, BIM (Babes in Mining)

Tracy Lydiatt (tlydiatt@gmail.com), Patricia Mesquita (paticia.mesquita@gmail.com), Anne Nolan (annieq@hotmail.com)
Statement of Collaboration

This thesis was written in a truly collaborative fashion. Working as a team allowed each thesis member to contribute experience and knowledge which reflected our passion and strengths respectively.

The evolution of the original topic idea was influenced by work experience and a desire to contribute to the mining industry’s growth in the right direction towards sustainability. We have each worked in the mining industry but in different roles – Patricia’s work as a social scientist, Annie’s work in Environmental, Health and Safety, and Tracy’s work in geological roles. We felt that combining these three areas of experience within the mining industry made a strong and diverse team.

During the literature review, we divided the work evenly, reading, and sharing our findings with the others. Interviews were sourced using existing contacts of each team member and several contacts were provided from our external thesis advisor, Dr. Joe Herbertson.

All team members contributed equally to capturing the results of the team’s work in the written thesis document. The process was facilitated through many group meetings where open dialogue on core ideas, mining processes viewed with the ‘glasses’ of the FSSD and our hopes and visions for the future of mining provided rich material. All members reviewed and revised each other’s work and contributed to all aspects of the thesis.

Developing a consensus based thesis document, in our opinion, yielded much stronger results than an individual attempt to develop the same material would have. We have learned an incredible amount about ourselves, each other and teamwork. It is our hope that we have contributed something valuable to the mining industry from our collaborative thesis effort.

Karlskrona, June 2008

Patricia Mesquita

Annie Nolan

Tracy Lydiatt
Executive Summary

This thesis was undertaken within the international Masters Program in Strategic Leadership Towards Sustainability at Blekinge Institute of Technology, Sweden.

The mining industry is faced with particular sustainability challenges to gain access to new exploration and mining development projects. Although the Mining Industry has taken up the challenge to identify and mitigate environmental and social sustainability challenges, there is considerable opportunity for mining projects to add value, build capacity and strengthen social fabric of the communities in which they operate, hence contribute to sustainable development. This is a different approach to minimizing impacts and ensuring compliance. This thesis investigates how the Framework for Strategic Sustainable Development (FSSD) can assist mining projects realise these opportunities in a transparent and participative process which is based on the scientifically-based principles to achieve a sustainable society. The scope of the thesis is limited to mining projects and will encompass the processes of: exploration; mine site development; extraction mining; primary processing (if any) that is completed on site; and end-of-life closure of the operation.

The Framework for Strategic Sustainable Development

The Framework for Strategic Sustainable Development (FSSD) was presented by Dr. Karl-Henrik Robèrt (2000). It is based on a five level generic model for planning in complex systems, and provides a clear structure and a process through which the interconnected nature of all aspects in a system can be honoured and includes:

i. Systems level,
ii. Success level,
iii. Strategic Guidelines level,
iv. Action level, and
v. Tools level

A major differentiator of the FSSD from the generic five level framework
is the consideration of society in the biosphere at the “system” level from which then develops the principles-based definition of societal success i.e. sustainability (Level 2 of the Framework) which is based on a scientifically agreed view of the world. In the sustainable society, nature is not subject to systematically increasing...

….concentrations of substances extracted from the Earth’s crust
….concentrations of substances produced by society
…degradation by physical means and, in that society
…people are not subject to conditions that systematically undermine their capacity to meet their needs.

(Holmberg et al. 1996, Ny et al. 2006)

Planning from a principles-based definition of sustainability does not provide a prescriptive “how to get there” but instead promotes innovation, creativity and flexibility. From a definition of success firmly based upon the principles for sustainability, an organization can “backcast” from the envisaged future to determine what strategies, actions and tools are necessary to take it from its current position to one that minimises its contribution to violations of the principles for sustainability.

Background and Research Question

The post-WWII period has seen unparalleled growth as never seen before in societal demand for food, fresh water, mined materials, timber and fibre. Whilst this increased demand has led to economic growth and well – being it has resulted in detrimental and sometimes irreversible negative impacts on the earth’s ecological systems. As a result the services ecosystems provide to sustain life such as clean air and water; fisheries agricultural productivity, forests and climate regulation continue to be degraded. The economic prosperity which economic growth has provided has not been evenly distributed throughout the world population and hence levels of abject poverty remain high (Millenium Assessment 2005). The issues of pollution, soil deterioration, poverty, desertification and freshwater depletion are all symptoms of deeper more systemic problems within society. These are complex problems which require systemic approaches to identify the root causes and prevent further degradation. However this doom and gloom scenario also presents an opportunity for forward-
thinking businesses to identify and invest in innovations and process that will halt the destruction of the ecosystem and preferably restore the degraded ecosystems.

To visualise this situation, we can refer to the metaphor of a funnel. The funnel represents the limits of the system where the resources society depends on are decreasing and pressure from global populations’ demands on the system is increasing. This can be visualised as entering deeper and deeper into the funnel. As time continues, the walls of the funnel are closing, thereby decreasing the room to successfully plan and manoeuvre towards a sustainable society. Therefore a methodology for planning towards a sustainable society is required.

The Funnel Metaphor (Robèrt et al. 2002)

The mining industry has made considerable efforts to reduce sustainability issues such as climate change, pollution, land degradation health & safety of workers and the community and human rights. However, in complex situations it can be very difficult to build consensus around solutions to specific problems if the desired outcome of sustainability has not been agreed upon, there is a potential to focus on the symptoms rather than the underlying causes.

This thesis seeks to identify the current development processes of a
mine project and considers recommendations within the FSSD for enhancements for planning of the mining project towards sustainability. The thesis attempts the question

“How can the Framework for Strategic Sustainable Development (FSSD) assist mining projects to contribute strategically to a sustainable society?”

Secondary research questions include: How do mining projects currently contribute to sustainable development?; What tools and concepts are currently used to assist mining projects contribute to sustainable development?; Are there ‘gaps’ (i.e. inability to assist organisations to move towards sustainability) within these concepts and tools?; What would guidelines for assessment based on backcasting from sustainability principles look like for developing a mining project?

The FSSD will be used as a lens to investigate how mining companies approach new projects that are at the very start of the mine’s life cycle.

Methods

The group’s prior experience within the mining industry was the basis for considering how the FSSD could be used to study the major issues confronting the industry. The methods used to answer the research questions included:

- Literature review to gain an understanding of current approaches to mine development
- Company and Industry interviews to collect data on the current reality of mine development decision making approaches

The current reality was analysed through the lens of the FSSD.

Step 1 – Understanding the system in which mining projects exist and defining success for them constrained by the four principles for a sustainable society.

Step 2 – Mining industry current reality for project development was viewed through the lens of the FSSD. Results were structured using the 5 levels of the FSSD. This step also includes the discussion section,
highlighting where gaps exist between the current reality and the industry through the lens of the FSSD.

**Step 3** – Presents recommendations for opportunities to bridge the gaps as outlined in the Step 2. It also provides mining relevant guidance on how specific actions resulting from a sustainability analysis should be prioritised. These are provided in Appendix C.

**Results**

A key for success in operating within the system (i.e. biosphere and all is subsystems) means mining companies understand their contributions and interdependencies within this system. Through their various business functions, projects and actions, mining companies must contribute to maintaining the health and robustness of this system for future generations. Current consequences of the rate and quantity of which mining companies bring elemental metals into the technosphere from the lithosphere result in greater flows than nature can deal with. Society has extracted and used metals from the lithosphere since the Bronze Age, however it is the large scale mining that has resulted in many of the sustainability challenges that are recognised with today’s processes. Additional to these impact on geochemical cycles, mining projects exist within complex social system in which they contribute to barriers that undermine the ability of people to meet their needs. Mining projects rely on and impact these ecological and social systems so it is in their best interest to promote their continued health. The discovery, extraction and processing of mineral resources is widely regarded as one of the most environmentally and socially disruptive activities undertaken by business (Peck and Sinding 2003). The environmental and social impacts of operating mines have been widely described throughout the literature and case studies. The results of our literature reviews and industry interviews highlighted the challenges that developing mining projects pose when considering the boundaries of the global ecological and social systems in which mining projects operate. This is particularly evident in the current times of a mining boom fuelled by the rapid industrialization and urbanization of the BRIC countries (Brasil, Russia, India and China) and their demand for metals for construction, infrastructure and telecommunications. These challenges include:

- Viability of the Minerals Industry
• Control use and management of land
• National and local social and economic development
• Environmental Management
• Materials Stewardship
• Access to information

Our studies have shown that the success of mining projects is typically judged on their ability to provide the required ore at the least cost within environmental licensing regulations and with minimal complaint from the local community. The current mining boom is pushing to achieve production in shorter and shorter timeframes to beat the competition to market and maximise return to shareholders. The legislative system drives the behaviour of compliance with allowable pollution standards, loss of biodiversity and acceptability of disruption of local communities in return for economic development. Generally the negative social and ecological impacts are “traded off” for the economic advantages brought by the mining project. The impact assessment process has recognised that a mining project will invariably change the ecological and social fabric of the region but the emphasis is on “doing less harm”.

Our research has highlighted that there are a number of strategies and actions used within the mining industry and some excellent examples illustrate the use of strategies such as dematerialization, substitution, detoxification, materials stewardship, equity and diversity.

The mining industry has many tools which have been developed in support of these strategies, resulting in actions for achieving certain goals within sustainable development. Many of these tools are very discipline specific, which prove to be useful in collecting data, monitoring actions implemented (guided by strategies for success), and are used in the reporting process. The information gathered through the use of tools provides rich material for company reports, documentation, applications for finance and licensing, and transparency initiatives to stakeholders.

Discussion

Our analysis of the current reality has shown that although the mining development process is addressing many of the sustainability issues they
are discipline specific and do not provide a strategic system based approach to addressing these issues. Understanding the social and ecological system of the project via the mandated impact assessments is often undertaken too late during the project phase. By this time expectations may have been raised, trust may be lost and ecological services may be damaged.

The vision of success for a mining project identifies the requirements for sustainability that can be “backcast” from in planning processes. The risk of not having a clearly defined end point to strive for is that resources may be misdirected and not lead to ultimate success. Focusing on what happened in the rear view mirror will not lead to the ultimate destination. The approach for the mining development projects is predominantly at the lower levels of the Five Level Planning Framework. There are many actions being implemented however they are not held together by a systems based strategy guided by a scientific-principled vision of success for achieving sustainability.

Our research also highlighted the fact that the mining industry had not yet embraced the Principles for a sustainable society due to barriers the language creates. Specifically the first Sustainability Principle as it is often interpreted to mean “no mining” however this is a simplistic and incorrect interpretation. It is the systematic increase of substances from the earth’s crust that results in unsustainability, not the extraction itself per se.

**Recommendations**

Our analysis has shown that in order for mining projects to have greater societal value in relation to their impacts, a more systematic approach to developing mining projects is recommended. A good understanding of the system in which they operate should be obtained at the outset of exploration and be built upon throughout each phase of the mining project. The earlier this is undertaken, the greater the chances are of building trust and creating buy-in for the project. It will also provide a good basis for the local community to exercise their free, prior and informed consent to accept the mining project. A vision of success for the mining project should be determined, constrained by the four principles for sustainability. This will result in creative tension and enhance innovation to identify solutions for current sustainability challenges within mining projects.
At each phase of the mining project, a sustainability analysis using the ABCD method is a simple way to “backcast” from the principles of success. This process should be undertaken to identify potential contributions to violations of the sustainability principles, brainstorm creative solutions and prioritise solutions in accordance with the potential of each to reach sustainability, to act as a flexible platform and to ensure a return on investment. Conducting a visioning exercise and ABCD analysis is an excellent opportunity for stakeholders to understand the implications of the project in the region, its contribution to achieving sustainability and potential opportunities for enhancing the community.

Conclusion

This thesis has attempted to illustrate the opportunity for mining projects to strategically contribute to sustainable development in their exploration, operations and post closure mining phases through backcasting from a principled definition of sustainability. Deriving mining activities and strategies in this way can allow for innovation, meaningful collaboration with relevant stakeholders and add value to society without systematically degrading the systems it depends upon. We believe this approach can enable many of the initiatives that mining companies are currently undertaking to be pulled together to identify interdependencies, holistically understand trade-off consequences and ensure that such actions assist mining projects to operate within sustainability constraints while adding value to society.

This thesis was limited in that the recommendations have not been tested in a practical application to an actual mining project. The process of a mine development project is lengthy and due to the short time frame of the thesis work a suitable project development was not available for testing.

As progress towards achieving a sustainable society advances, the challenge is to create maximum value for society without contributing to systematic degradation of life supporting resources through mining processes. Thus the actual process of mining must move away from unsustainable practices as described throughout this thesis. In a sustainable society the role of virgin mining will be one which “tops up” the metals stock in society needed due to increasing demand. The current trend away from the linear system of using metals only once will continue to
incorporate much greater reuse of metals at the end of their initial applications. This will require that the product stewardship of metals currently in the technosphere is greatly enhanced and expanded i.e. we look after what we have already got. Applications for metals should be carefully considered as well as potential unconventional sources of metals able to be mined in the sustainable future.
Glossary

**ABCD Analysis:** Refers to a strategic tool for applying ‘backcasting from principles’ to a planning endeavour. It includes: A) understanding the system and creating shared mental models B) assessing sustainability performance today C) establishing a vision of success and brainstorming solutions and D) prioritizing strategic actions (Holmberg and Robèrt 2000, Ny et al. 2006).

**Anthropocentric:** Refers to seeing things in human terms, especially judging things according to human perceptions, values and experiences.

**Anthropogenic:** Relating to or resulting from the influence humans have on the natural world.

**Beneficiation:** Refers to the process of concentrating or enriching of the valuable minerals in an ore.

**Bioaccumulation:** Generally refers to the situation where substances, such as pesticides or other persistent organic chemicals, accumulate in an organism. The process of accumulation often occurs through respiration, food intake, and skin contact with the substance. Typically, the organism cannot use its natural systems to process the substances quickly enough to reduce toxicity or it is not biologically equipped to.

**Backcasting:** The planning approach that plans from ‘success’, starting with a desired outcome in mind and identifying steps required to achieve the desired outcome.

**Backcasting from principles:** The planning approach of backcasting performed from a set of non-overlapping principles that are general enough to be helpful in the coordination of different sectors of society and in business, as well as to cover relevant aspects of sustainability (Holmberg and Robèrt 2000).

**Biosphere:** Refers to the whole area of the Earth’s surface, atmosphere and sea that is inhabited by living things. The biosphere is a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit (WRI 2007).

**Dematerialisation:** In this context, refers to the absolute or relative
reduction in the quantity of materials used in serving economic functions in society. Specifically related to the design and development of mining projects and their related processes.

**Detoxification:** In this context, refers to the process of counteracting or removing the toxic properties of mining processes and/or their resulting waste.

**Diversity:** Refers to the societal and cultural diversity that lies at the foundation of our species’ ability to adapt and survive in many different conditions.

**Eco-efficiency:** Creating more goods and services with ever less use of resources, waste and pollution (WBCSD 1991).

**Eco-toxic:** Causing severe damage to the environment and is typically used in reference to chemicals or pollutants and their related affects on the environment or humans.

**Ecological Services:** Services provided by the ecosphere on which humans are dependent. Services are classified into three different categories defined by their function: provisioning (i.e. food, freshwater), regulating (i.e. climate, disease, water flow), cultural (i.e. recreation, spiritual enjoyment), and supporting (i.e. nutrient cycling).

**Ecosphere:** Also referred to as *biosphere*.

**Entropy:** The measure of the randomness of molecules in a system.

**Equity:** Actions, treatment of others, or a general condition characterized by justice, fairness and impartiality.

**Feasibility:** In this context, refers to the process of evaluating a mineral deposit and determining if the resource contained, logistics and processes which to extract the resource will prove to be economically viable within defined social and environmental constraints.

**Forecasting:** A planning approach in which past results are reviewed and extrapolated into the future as something against which progress can be measured.

**Free Prior and Informed Consent (FPIC):** Refers to the right of a local
community to be informed about mining operations on a full and timely basis and to approve a mining operation prior to the commencement of operation

**Greenhouse Gases (GHGs):** Emissions into the atmosphere of gases that affect the temperature and climate of the earth's surface. The main greenhouse gases emitted due to human activity are carbon dioxide (CO$_2$), methane (CH$_4$) and nitrous oxide (N$_2$O).

**Human Needs:** Presented as needs which are few, finite, classifiable and ubiquitous through time and culture. The 9 basic human needs are classified as: subsistence, protection, affection, understanding, participation, leisure (or idleness), creation, identity and freedom (Max-Neef 1991).

**Law of Conservation of Matter:** States that in a closed system, matter cannot be created nor destroyed.

**Law of Conservation of Energy (First Law of Thermodynamics):** States that energy cannot be created nor destroyed, it only changes form.

**Lithosphere:** A layer of solid, brittle rock making up the outer 100 kilometers of the Earth, encompassing both the crust and the outermost part of the upper part of the Earth’s core. It is the layer from which humans extract materials used in society.

**Material Stewardship:** Responsibly providing materials and supervising material flows to create maximum societal value and minimum impact on humans and the environment.

**Persistent Bioaccumulative Toxins (PBT):** Toxins which are man-made or result from human processes which accumulate in nature due to their resistance to chemical and/or metabolic degradation.

**Photosynthesis:** The process by which green plants use light to synthesize organic compounds from carbon dioxide and water. In the process oxygen and water are released. 

\[
6 \text{CO}_2(g) + 12 \text{H}_2\text{O}(l) + \text{photons} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(aq) + 6 \text{O}_2(g) + 6 \text{H}_2\text{O}(l)
\]

**Satisfiers:** Refers to categories of having, being, doing or interacting in ways which fulfil the 9 basic human needs as presented by Chilean economist, Manfred Max-Neef. Satisfiers can be positive or negative in
relation to whether they actually achieve fulfilment of needs in a productive, non-damaging way to the individual or others. Satisfiers can be instituted from a ‘top-down’ (governance) or a ‘bottom-up’ (grassroots) direction.

**Second Law of Thermodynamics:** Simply stated, this law refers to the tendency of energy in an isolated system to spread or dissipate over time, therefore being less available to do work.

**Strategic Sustainable Development:** In this context, refers to the process by which step-by-step strategies are formed for individuals or organisations by ‘backcasting from sustainable principles’ in order to achieve a vision of success in the future.

**Sustainability Principles:** Refers to basic principles for socio-ecological sustainability presented by scientists to define the minimum requirements to achieve a sustainable society. The principles are derived from basic laws of science and fundamental human needs, were developed through consensus and published in peer-reviewed journals (Holmberg & Robèrt 2000).

**Systems Thinking:** Refers to understanding the whole system, its sub-systems and their recurring patterns and the relationship between its sub-systems. Used in finding solutions for complex problems.

**Substitution:** The action of changing one material or substance for another with the intention of reducing harmful impacts of the original substance for a less harmful one.

**Technosphere:** Refers to a subsystem contained within the biosphere where materials, products and human controlled industries exist and interact.

**The Natural Step (TNS):** Refers to an international non-government organisation (originated in Sweden) which guides companies, communities and governments onto an ecologically, socially and economically sustainable path.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>AIDS</td>
<td>Acquired Immunodeficiency Syndrome</td>
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<tr>
<td>BC</td>
<td>Before Christ</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
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<td>CSR</td>
<td>Corporate Social Responsibility</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>EHS</td>
<td>Environment, Health and Safety</td>
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<tr>
<td>ESR</td>
<td>Ecosystems Services Review</td>
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<tr>
<td>FSSD</td>
<td>Framework for Strategic Sustainable Development</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHG</td>
<td>Green House Gases</td>
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<td>HIV</td>
<td>human immunodeficiency virus</td>
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<td>ICMM</td>
<td>International Council for Mining and Metals</td>
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<td>IFC</td>
<td>International Finance Corporation</td>
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<td>IISD</td>
<td>International Institute for Sustainable Development</td>
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<td>ISO</td>
<td>International Standards Organisation</td>
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<tr>
<td>LCA</td>
<td>Life-cycle Analysis</td>
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<tr>
<td>MAC</td>
<td>Mining Association of Canada</td>
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<tr>
<td>MMSD</td>
<td>Mining, Metals and Sustainable Development</td>
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<tr>
<td>NGO</td>
<td>Non-Government Organisation</td>
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<td>NPI</td>
<td>Net Positive Impact</td>
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<td>Acronym</td>
<td>Description</td>
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<td>PBT</td>
<td>Persistent Bioaccumulative Toxins</td>
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<tr>
<td>PDAC</td>
<td>Prospectors and Developers Association of Canada</td>
</tr>
<tr>
<td>PhD</td>
<td>Doctor of Philosophy</td>
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<tr>
<td>PWC</td>
<td>Pricewaterhouse Coopers</td>
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<tr>
<td>SEAT</td>
<td>Socio-Economic Assessment Toolbox</td>
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<tr>
<td>SP 1</td>
<td>Sustainability Principle 1</td>
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<td>SP 2</td>
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<td>SP 4</td>
<td>Sustainability Principle 4</td>
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<td>SD</td>
<td>Sustainable Development</td>
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<td>SIA</td>
<td>Social Impact Assessment</td>
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<td>TNS</td>
<td>The Natural Step</td>
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<td>UK</td>
<td>United Kingdom</td>
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<td>UN</td>
<td>United Nations</td>
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<tr>
<td>WBCSD</td>
<td>World Business Council for Sustainable Development</td>
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<td>WCED</td>
<td>World Council of Economic Development</td>
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<td>WRI</td>
<td>World Resources Institute</td>
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1 Introduction

1.1 Challenges for a Sustainable Society

The past fifty years have seen an unparalleled growth in societal demand for food, fresh water, energy, timber and fibre as never before in history. Whilst this increased demand has led to economic growth and well-being, it has also resulted in detrimental and sometimes irreversible negative impacts on the earth's ecological systems. As a result, the services that the ecosystems provide to sustain life such as clean air and water, fisheries, agricultural productivity, forests, and climate regulation continue to be degraded to the point they are no longer sustainable. These changes are reaching a tipping point where the non-linear affects of ecological degradation cannot be adequately predicted (Millennium Ecosystem Assessment 2005). This also presents an opportunity for business to identify and invest in sustainability driven innovation.

The earth's natural systems are losing their capacity to clean up the mess that the industrial society has created. Deforestation removes natures' ability to sequester carbon. The increasing rate of fossil fuel combustion exceeds the sequestering capacity of the remaining natural sinks and results in a build up of atmospheric carbon leading to climate change. Similarly natural systems have no defence against the multitudes of anthropogenic-developed substances and waste hence these too build up in the ecosystems to levels at which the consequences cannot be predicted. Climate change, soil deterioration, poverty, desertification, and freshwater depletion are all symptoms of deeper, more systemic problems within society which are the mechanisms of our current non-sustainability.

Tackling each of these problems in isolation will not get to the root cause of the problem, i.e. the current design of our present societal system is not fundamentally sustainable. Although the increase in economic growth has resulted in improved living standards, these benefits have not been distributed fairly. Levels of poverty remain high and many people do not have adequate access to basic ecological services such as fresh water. More than 6 million children die from preventable diseases and more than 1 billion people live on less than $1 per day (United Nations Development Project 2005). Declining soil fertility, land degradation and the AIDS pandemic have led to 23% decrease in food production per capita in the last 25 years even though the population has dramatically increased (United...
To visualise this situation, we can refer to the metaphor of a funnel. The funnel represents the limits of the system where the resources society depends on are decreasing and pressure from global populations’ demands on the system is increasing. This can be visualised as entering deeper and deeper into the funnel. As time continues, the walls of the funnel are closing, thereby decreasing the room to successfully plan and manoeuvre towards a sustainable society. Figure 1.1 below illustrates this metaphor.

![The Funnel Metaphor](image)

### Figure 1.1 The Funnel Metaphor

#### 1.2 Shifting Mindsets

Changing the way we do business is critical to our success as a society. This encompasses a shift in mindset from an anthropocentric view to one where society recognises its interconnectedness to the biosphere that supports it. Understanding the system we operate in from a holistic view helps businesses to understand the challenges we face, related opportunities and the strong business case for sustainability. Figure 1.2 depicts the fundamental relationship between individuals, within organisations within communities within society within the biosphere. This shows that the smaller circles are ultimately dependant upon the functioning of the larger circles. Where any of the smaller circles undermine the continued functioning the larger circles, there is potential to weaken the basis for
existence - hence leading to non-sustainability (Gibson 2005).

Interdependent parts of the system which are all contained within the biosphere, supported by its ecological life-sustaining systems, and at times perceived to be independent from each other. The undermining of any of the nested circles ultimately weakens the whole system’s robustness.

Author Bob Willard, recognises that business is a significant contributor to the 21st century ecological and social challenges mentioned above. He also notes that corporations have the power and particularly multinational corporations are the only institutions on the planet that are large enough, well-managed enough and resourceful enough to address global sustainability issues - if they have the will (Willard 2005). This is evidenced by large business finding innovative ways of doing business and specific institutions addressing sustainability such as the World Business Council for Sustainable Development (WBCSD).

1.3 Purpose

The mining industry in particular faces its own specific challenges for continued operations. Change is not an easy process and will require organisations in the mining industry to show courage in re-evaluating the underlying assumptions of how they do business and their future role in contributing value to society.

Mining projects, serving as a stepping-stone, have significant opportunities to add business value, build capacity and strengthen social fabric whilst maintaining and restoring the ecological capacity to provide the essential services for societal continuity. The purpose of this thesis is to examine how the Framework for Strategic Sustainable Development (FSSD) (Holmberg & Robèrt 2000, Robèrt et al. 2002) can assist mining projects realise these opportunities.
1.4 Scope and Limitations

Scope

The thesis will focus on the beginning stages of a commodity's life cycle, also known as the 'process stewardship' section of mined material life cycle. It will encompass the processes of: exploration; mine site development; extraction mining; primary processing (if any) that is completed on site; and end-of-life closure of the operation. Figure 1.3 below shows the full life cycle process of a commodity (ICMM 2006). The inset in Figure 1.3 provides a visual representation of the time line of a mine development project life cycle.

Limitations

This thesis seeks to identify the current development processes of a mine project and considers recommendations within the Framework for Strategic Sustainable Development (FSSD) for enhancements for planning towards sustainability. The recommendations are theoretical and due to the time taken to develop a mine project they have not been applied in practice. Within time constraints we sought expert opinions within the mining industry on the usefulness of this approach. Additionally, the type of...
mining project was limited to only include base and precious metal projects; excluding coal, uranium, precious gems and industrial minerals.

1.5 Strategic approach to Sustainable Development

The mining industry has made considerable efforts in numerous sustainability issues such as climate change, pollution, land degradation/rehabilitation, mine closure, health & safety and human rights.

If we consider the analogy of a tree where the details of these individual issues are represented as the leaves and the trunk and branches represent the underlying root causes of the problems, a more holistic approach to problem solving occurs. Many ‘leaves’ exist, populating the industry with a large quantity of details on problems. However the tendency to “get lost in the leaves” presents a problem when companies work to solve their challenges. Which issues to approach first? How do the challenges affect the companies? Which issues have the strongest regulatory focus and related risks? Where do opportunities exist within these challenges? Without an understanding of the root causes of problems, i.e. the trunk and branches, the biggest threat to companies is becoming overwhelmed by details, forcing reactionary measures, thus potentially missing opportunities and spending valuable time and resources just to “keep up”.

![Tree Metaphor for Complex Systems]

Leaves = Details

Truck & Branches = Basic Principles

Figure 1.4 Tree Metaphor for Complex Systems

Getting “lost in the leaves” can hinder an organisations' ability to be strategic in their actions, not allowing them to move from a reactive to a proactive business position.
1.5.1 Framework for Strategic Sustainable Development

The Framework for Strategic Sustainable Development (FSSD) was presented by Dr. Karl-Henrik Robèrt (2000). It is based on a five level generic model for planning in complex systems, and provides a clear structure and a process through which the interconnected nature of all aspects in a system can be honoured and includes:

(i) the Systems level, (ii) the Success level, (iii) the Strategic Guidelines level, (iv) the Action level, and (v) the Tools level (Robèrt 2000). The framework and its application to sustainable development is shown in Figure 1.5 below.

![Figure 1.5 Five-level framework comparing the generic model to the FSSD (Holmberg and Robèrt 2000)]

However the FSSD builds on this generic model by envisaging the future success as one which is constrained by the socio-ecological conditions for sustainability.
1.5.2 Non-sustainability and Principles for a Sustainable Society

Different activities in society participate in society’s contributions to violations of so-called ‘principles’ for sustainability as determined by Holmberg and Robèrt (2000). As discussed in the previous section, non-sustainability has been progressing for many decades, marked by increased demand on natural resources, placing pressure on ecological services and a build-up of waste beyond the assimilation capacity of the natural environment, therefore it is logical to design the sustainability principles as restrictions, i.e., principles that determine what human activities must not do. Additional to constructing the principles for sustainability as constraints, they must also be:

1. Based on a scientifically agreed upon view of the world
2. Necessary to achieve sustainability
3. Sufficient to cover all aspects of sustainability
4. Concrete enough to guide actions and problem solving, and preferably
5. Mutually exclusive to facilitate comprehension and monitoring

(Ny et al. 2006)

Understanding that no one can predict the future, searching for a desired future based on principles of which any sustainable society would meet is a viable alternative. By defining the basic principles through which a society would be sustainable in the future, this would allow for innovation, creativity and flexibility in planning the path to get there (i.e. sustainable development). Therefore, in a sustainable society the following principles (in no particular order) would hold true:

In the sustainable society, nature is not subject to systematically increasing…

I. …concentrations of substances extracted from the Earth’s crust
II. …concentrations of substances produced by society
III. …degradation by physical means and, in that society
IV. …people are not subject to conditions that systematically undermine their capacity to meet their needs.

(Holmberg et al. 1996, Ny et al. 2006)

Such principles can be helpful when developing reliable non-overlapping indicators for monitoring development, when coordinating various measures from different sectors of the society, or within individual firms with each other, and when handling trade-offs in an optimized way.
(Holmberg and Robèrt 2000). Using the above principles for sustainability to create a new mental model and vocabulary, organisations can bring their stakeholders together to plan for success, innovate and foster creativity.

From this envisaged sustainable future, an organisation can "backcast" to identify the steps and actions it can take to move towards the sustainable future over a timeline. Backcasting from a vision of a sustainable future provides a strong pull force, resulting in creative tension which encourages innovation and creativity to attain the goal. This approach is in contrast to forecasting from past and present trends which contributed to unsustainability.

1.5.3 Vision and Backcasting

There is a crucial need today for compelling images of a future we truly want to create: an economic system that operates in accord with natural principles and generates no waste, an energy system powered entirely by net energy from the sun, [a regenerative food system that provides nourishment to all individuals], and an ethic of being common villagers who must all live together on an increasingly interdependent planet ... this means moving from a compliance mentality of doing no harm to the aggressive creation of products, processes and companies that are truly creating restorative and enduring wealth – leaving communities and larger living systems in better condition, not worse. (Senge et al. 2006, 8)

The fundamental distinguishing characteristic of the most enduring and successful corporations is that they preserve a cherished core ideology while simultaneously stimulating progress and change. A good vision builds on the interplay between these two forces: it defines core ideology (i.e. what we stand for and why we exist) and sets forth envisioned future (i.e. what we aspire to become, to achieve, to create) (Collins and Porras 1994). Consideration of the highest level of a system; the ecosystem and its services, and the basic fundamental needs humans are important constraints for visioning as depicted in Figure 1.6 below. These aspects give context to the core ideology and envisioned future, which ultimately guides the direction of development with a more holistic view.
Consideration of these two high level aspects during construction of the visioning framework is a valuable step towards integrating the value of ecological services and human needs into business vision, the foundation of subsequent policies and decision-making processes (modified from Collins and Porras 1994)

Figure 1.6 Modified Vision Framework.

**Backcasting from an Envisioned Future**

*We cannot solve our problems with the same level of thinking that we used when we created them.* —Albert Einstein

Planning for the future is an approach used by many organizations, communities and businesses to direct their development, allocate resources, and assist in decision-making. Often the planning approach is to review past results and extrapolate them into the future (i.e. forecasting). However, planning for the future based on reviewing the past is not sufficient to fix the underlying systemic issues that created the problems in the first place. An example of this is the plan to reduce CO\textsubscript{2} emissions by X %, which does not address the systemic cause of increases in CO\textsubscript{2}.

The challenge of planning for a sustainable society is to create the plan in such a way where the actions contributing to non-sustainability are systemically eliminated. Backcasting is a method in which the future desired conditions are envisioned and steps are then defined to attain those conditions, rather than to take steps that are merely a continuum of present methods extrapolated into the future (Holmberg and Robèrt 2000). Typically backcasting is applied on long-term complex issues, involving many aspects of society as well as technological innovations and change. An approach that focuses on the root of the problem to be solved rather than on present conditions and current trends, is better suited to achieving
real solutions than a traditional forecasting approach (Dreborg 1996).

The differences between using forecasting and backcasting as a main planning perspective can be described as sailing a ship with the aide of a lantern (forecasting) verses a lighthouse (backcasting). It is not difficult to imagine the benefits of being guided by a long-term vision (Section 1.3) to avoid many obstacles along the journey rather than picking a way through them in an ad hoc way. For an industry such as mining, the usefulness of being able to ‘get ahead’ of current trends, avoid costly delays in operations often caused by social disruptions, permitting, and financing to smoothly move ahead of competitors should be of great interest.

![Figure 1.7 Forecasting versus backcasting approaches to planning.](image)

*Figure 1.7 Forecasting versus backcasting approaches to planning. The rocks represent obstacles to achieving a particular goal. Within the mining industry, these potential obstacles are but not limited to: social license to operate, climate change, lack of skilled labour, and ease of securing permits, financing and insurance.*

While at times, forecasting is more practical in the short-term, the advantage to the organization conducting the planning occurs when backcasting is the dominant method for planning, complemented by forecasting for shorter term movements, as illustrated by the small arrows in Figure 1.7 above. This approach to planning; using backcasting from a long-term vision which considers the value of human needs and ecological services, combined with forecasting in the short-term helps to pull the organization towards its goal through a carefully planned step-by-step manner.
Combined with the five-level framework for planning (Section 1.5.1), backcasting becomes an important part of the ‘Strategy’ level within the FSSD described above. The defined success level provides the future from which to backcast from and derive strategies on how to achieve the success.

1.5.4 Considerations for the mining industry

Sustainable development issues have a fundamental influence over key drivers of profitability for mining companies. They influence, for example, whether companies gain access to additional land and resources, how acceptable their products will be to consumers and regulators in the marketplace and the terms for accessing capital and gaining competitive insurance rates. A recent analysis published by the public relations firm Hill & Knowlton as cited in Cameron and Goldsmith (2007) reporting on the views of 282 global investment analysts, noted that “companies failing to look after the reputational aspects of performance will ultimately suffer financially”.

Utilising a principles based definition of sustainability would assist the mining industry by having a shared mental model and a common vocabulary for sustainability. The mining industry has made considerable steps towards becoming more sustainable as it utilises numerous initiatives, tools to and monitor, assess and report achievements. Most mining company sustainability reports show there is an emphasis on a year-by-year, continual improvement for sustainability performance. Thus there is an opportunity to become more strategic in its planning, thereby implementing actions pulled from the vision of a sustainable society, rather than a gradual improvement of the current situation.

There are opportunities for the industry to ensure the intergenerational distribution of wealth created by their operations within the constraints of sustainability. Concurrently, another opportunity exists for mining organisations to re-evaluate their business models and how they will survive beyond the finite life of the resources they depend on. Numerous mining companies have begun this important transition in their corporate mindset as evidenced by their corporate reporting and public commitments to sustainability, thus stated in company reports. This thesis seeks to add to this work and strengthen the contribution of mining projects in a sustainable society.
2 Methods

2.1 Research Design

The group’s prior experience within the mining industry was the basis for considering how the FSSD could be used to study the major issues confronting the industry. From there, many questions existed about the specific area of focus within the mining industry and how to choose a realistic size of project whose scope matched the time limitations that existed. The Qualitative Research Design process from Maxwell (2005), aided the group’s initial research design process.

Using this method of analysis to design the thesis process was extremely useful, helping guide the selection of a specific topic within mining as reflected in a primary research question. Coming to agree on the primary research question was a non-linear path with many derivations of order, frequency and intensity of discussion around the additional questions:

- Why this topic for study?
- What did we think was going on in the industry currently?
- What methods could we use to determine this?
- How might we be wrong?

These questions have guided the evolution of this thesis through continuous and dynamic movement through each quadrant above as more information was gathered, filtered through the FSSD and evaluated, always guided by closely adhering to the primary research question.

2.2 Research Questions

This thesis project attempts to answer the question:

“How can the Framework for Strategic Sustainable Development (FSSD) assist mining projects to contribute strategically to a sustainable society?”

The FSSD will be used as a lens to investigate how mining companies approach new projects that are at the very start of the mine’s life cycle.
Secondary research questions include:

- How do mining projects currently contribute to sustainable development?
- What tools and concepts are currently used to assist mining projects contribute to sustainable development?
- Are there ‘gaps’ (i.e. inability to assist organisations to move towards sustainability) within these concepts and tools?
- What would guidelines for assessment based on backcasting from sustainability principles look like for developing a mining project?

2.3 Literature Review

A literature review was undertaken of relevant peer-reviewed journals, case studies and industry standards/best practices to obtain an understanding of the current approaches to the process of mine development and how, if at all, sustainable development aspects are considered.

Objectives:

- Gain an understanding of the current methodologies, frameworks and guidelines currently used during mine site project development;
- Identify the application, advantages and possible shortcomings of these tools/methodologies in relation to the FSSD;
- Utilise the FSSD as a lens to examine the robustness of these methodologies in terms of a systems approach and a holistic definition of sustainability

2.4 Company and Industry Interviews

A number of representatives from mining companies, consultants, industry associations, an engineering company, PhD student and one NGO involved in mining development were interviewed. The interviews were conducted to collect data on the current reality of the decision making processes, mental models and tools/strategies related to mine project development.
Objectives:

- Identify challenges currently faced by the companies
- Identify the definition of sustainability used by the companies
- Identify criteria for determining their definition of sustainability
- Understand how the companies’ sustainability objectives get incorporated at the project level
- Understand the challenges the companies face in implementing sustainability aspects at the project level
- Identify how the companies demonstrate to stakeholders that the project is contributing to sustainable development
- Understand corporate mindset and drivers for sustainability efforts
- Understand how the companies determine the extent of responsibility and sets boundaries for the project

A list of persons interviewed is presented in Appendix A. The list of detailed interview questions is found in Appendix B.

2.5 Report and Analysis of Results

Data from the interviews, personal experience and literature reviews were collected and structured using the five levels of the framework for strategic sustainable development. Structuring the data in such a way, allowed for the current reality of mine project development to be easily compared to an ideal planning process in order to identify possible gaps as seen in Figure 2.1 below.
Figure 2.1 Using the Funnel Metaphor to visualise current gaps in the planning for mining projects

Figure 2.1 describes how using the methods suggested in the Framework for Strategic Sustainable Development can assist mining projects to move towards contributing to a sustainable society.

Several steps were taken to evaluate the current reality for mining project development, and how the FSSD could be used to stimulate innovation and creativity.

**Step 1** – Understanding the system in which mining projects exist and defining success for them constrained by the four principles for a sustainable society.

**Step 2** – Mining industry current reality for project development was viewed through the lens of the FSSD. Results were structured using the 5 levels of the FSSD:

1) System
2) Success
3) Strategy
4) Actions
5) Tools

This step also includes the discussion section, highlighting where gaps exist between the current reality and the industry through the lens of the FSSD.

**Step 3** – Presents recommendations for opportunities to bridge the gaps as outlined in the step 2. This step also provides guidance on how to prioritize
actions to ensure maximum leverage and success. The relevance of these questions to the mining industry is provided in Appendix C.

The structure of this report reflects this approach.

2.6 Development of Guidance Document

In an effort to outline the procedure for applying the FSSD for mining projects, a guidance document was developed (see Appendix C).

While all aspects of sustainable development are important, in some cases, depending on the location of the mining project, certain challenges may require different emphasis in order to successfully develop the project. For example, if the local governance is weak, there may be more focus put on capacity development initially. Another example would be development within a sensitive biodiversity area where local communities have traditional land uses. In this situation, it might require great emphasis on community engagement and scientific studies of the biodiversity aspects.

The questions for innovation provided in the guidance document were designed to allow for the consideration of all sustainability aspects involved in mining project development, regardless of location and provide guidance on how to prioritize short term actions in connection with long term goals.
3 Results

3.1 Understanding the System

At the highest system level, all individuals, communities, and organizations including mining companies exist within the biosphere which provides life supporting services. A key for success in operating within the system means mining companies understand their contributions and interdependencies within this system. Through their various business functions, projects and actions, mining companies must contribute to maintaining the health and robustness of the system for future generations. This is key to their survival and should be the heart of their business philosophy, guiding their business strategy, investments and actions.

Defining success is crucial for strategic planning in complex systems, yet in order to define success is it essential that the “system” in which the planning is to occur is understood in sufficient detail (Robèrt et al 2004). A mining project comprises exploration, feasibility determination, design, planning and management of operations for the development, production and eventual reclamation of a finite mineral resource. For a mining project to be “successful” (to be discussed in a later section of this document) a full understanding of the system the mining project exists in is required to determine its success.

A mining project exists within the ecological and social systems of the biosphere and hence is subject to the natural laws and scientific principles of this system. The biosphere is a complex system that comprises a large number of interactions within and between its subsystems and components. These interconnected relationships are at many scales from the microscopic to the cosmological with links that involve positive and negative feedbacks. These dynamic relationships are very complex and we will never understand fully how they work or how they will respond to interventions (Kay et al. 1999). However, Robèrt et al. (2000), through scientific consensus have identified fundamental principles of the ecological and social systems, in which a mining project is a part.
3.1.1 Basics of the Ecological System

The fundamentals of the laws of nature are described in the textbox below:

The biosphere is a closed system with respect to matter but open with respect to energy. Light energy from the sun is received by the earth and heat energy radiated back.

Matter and energy cannot be created nor destroyed, however they are transformed. The materials that constitute the current world are those that, in essence are the same that have been around since the earth was formed. However they have been transformed according to the Law of Conservation of Matter and the Law of Conservation of Energy.

The Second Law of Thermodynamics states that matter and energy tend to disperse and in order to reverse consequences of this energy must be introduced into the system from a source outside the system i.e the sun.

Society consumes the concentration, structure and purity, but not matter itself due to the Conservation Laws.

Increases in order or material quality are produced by sun driven mechanisms i.e. photosynthesis

Over 99% of the lithosphere is made up of eleven elements – oxygen (47%), silicon (28%) aluminium (8%) iron (5%) calcium (3%) sodium (3%) potassium (3%) magnesium (2%) with titanium, hydrogen and phosphorous (totalling <1%). Carbon, manganese, sulphur, barium, chlorine, chromium, fluorine, zirconium, nickel, strontium and vanadium are present in trace amounts from 0.1 to 0.02 % (Pidwirny 2006). These elements commonly exist in the form of compounds rather than the free-state. Elements naturally are brought into ecosphere through the processes of volcanic eruption and weathering and are reintroduced into the lithosphere through sedimentation. Anthropocentric activities such as mining have increased the rate at which elements are bought from the lithosphere into the ecosphere.

Holmberg (1996) compares the anthropogenic flows from the lithosphere to the ecosphere with the natural flows through weathering and sedimentation from the ecosphere. This study illustrates that the there is
considerable difference in metals that are abundant in nature such as aluminium and iron and those that are scarce in nature such as mercury and cadmium. Nriagu (1990) estimates that the anthropogenic emissions of heavy metals (lead, cadmium, vanadium and zinc) exceed the fluxes from natural sources by 3-28 fold and that emissions from arsenic, copper, mercury and antimony amount to 100-200% of emissions from natural sources. There is extensive research data on the toxicity of individual metals, however the basic principle is that heavy metals are being released into the ecosphere through societal products and processes at a faster rate than nature re-sequesters them into the earth’s crust. This overall accumulation in natural systems causes ecological problems if the concentrations become excessive. The concentrations that can be accepted in the ecosphere without jeopardising our health and economy in the long run will depend on properties such as eco-toxicity and bioaccumulation (Robèrt et al 2004). Therefore the fundamental operation of the system dictates that materials from the lithosphere should be used in a manner that prevents their accumulation in nature and that they are used in products and process that can prevent loss from the technosphere through recycling and re-use rather than allowing them to be released to the atmosphere, soil and water.

The afore mentioned natural laws defining ecological systems underpin society. Therefore there is a need to understand the relationships between the two systems.

3.1.2 Basics of the Social System

In order to understand the dynamic relationships between the ecological and social systems, it is important to reinforce that there are three characteristics widely referred to in science as determining the efficiency or fitness for purpose of all systems in nature, including social systems; they are interdependence, self-organisation and diversity. These are the overriding features that all living systems have in common, from the most complex to the most simple (Robèrt et al. 2004).

Interdependency relates to the fact that every system is affected by the actions and responses of its component parts, or sub-systems. It means that each “molecular” composition of the social fabric, i.e. micro-organisations, local spaces, human scale relations, is linked to a bigger part of the system
(communities, cities, regions, ecosystems, societies) affecting and being affected by them positively or negatively.

The Diversity feature refers to societal and cultural diversity that lie at the foundation of our species’ ability to adapt and survive in many different conditions. Therefore, resilience of a system comes from its ability to accommodate and promote diversity and from the greater adaptive capacity that diversity provides diversity.

The third feature refers to Self-organisation, people’s in-built capacity to organize themselves in ways that increase their possibilities of satisfying their needs, making the system function as long as the respective parts of that system have the opportunity to exercise that capacity. Human beings organize themselves in complex social structures in order to accomplish that.

The distinction made between needs and satisfiers is one of the main contributions that Manfred Max-Neef (1991) makes to the understanding of human needs. Human needs are few, finite, classifiable, and are constant through all human cultures and across historical time periods. What changes over time and between cultures is the way these needs are met. It is important that human needs are understood as a system in the sense that they are interrelated and there is no hierarchy.

Max-Neef classifies the fundamental human needs as: subsistence, protection, affection, understanding, participation, leisure (or idleness), creation, identity and freedom. Needs are also defined according to the existential categories of being, having, doing and interacting. The matrix in Appendix D is as an example and it is not meant to exhaust the possibilities.

Satisfiers may also be classified in different categories: they can be: 1) violators or destroyers, promoted as satisfying a particular need but in fact destroying the possibility of satisfying that same need and other needs; 2) pseudosatisfiers, which are elements that generate a false sense of satisfaction of a given need; 3) inhibiting satisfiers, those that generally oversatisfy a given need, reducing the possibility of satisfying other needs; 4) singular satisfiers, those that satisfy a particular need; 5) or synergic satisfiers, those that satisfy a given need, stimulating and contributing to the fulfilment of other needs.

One valuable distinction amongst the categories of satisfiers is that the
first four are exogenous to civil society as they are usually imposed, induced, ritualized or institutionalized, traditionally generated at the top and advocated for all, while endogenous satisfiers (last category) result from liberating processes generated by the community at the grassroots level. As exogenous satisfiers we find: arms race, while ostensibly satisfying the need for protection, destroys subsistence, participation, affection and freedom; formal democracy, which is supposed to meet the need for participation often disempowers and alienates; commercial television, while used to satisfy the need for recreation, interferes with understanding, creativity and identity. As endogenous satisfiers we find: self-managed production; popular education; democratic community organisations; preventative medicine; meditation; educational games.

3.1.3 Ecological Services

Society depend upon local, regional and global ecosystems services to meet their needs. Mining projects depend and significantly impact upon ecological services. Natural systems are the foundation for all human systems because we rely on these to provide a wide variety of life-supporting services. Overexploitation of life-supporting resources can alter the dynamic equilibrium of an ecosystem, and, therefore, lead ultimately to either extinction or adaptation of life supported by those resources. The Millennium Ecosystem Assessment (2005) has categorized ecosystem services as:

- Provisioning – food, fibre, biomass, freshwater, genetic resources, natural medicines
- Regulating - air quality, climate regulation, water regulation, erosion control, pest, disease, waste regulation
- Cultural - recreational, ethical values
- Supporting - nutrient recycling, primary production water cycles

In order to understand the system, in which a mining project is operating, it is necessary to understand the ecological services that the community depends upon and how the mining project will impact upon the communities’ access, utility and maintenance of these services.

3.1.4 Defining success
A vision of success is required in any complex planning endeavor in order to be effective in reaching an end goal. Senge (1990) describes a vision as a force of impressive power which, if it is compelling enough, spurs people into action. When people truly share a vision they are bound together by a common caring. It is essential for an organization moving towards sustainability to create a vision which will result in creative tension that drives innovation and inspiration to achieve sustainability. Holmberg & Robèrt (2000) have recognized that a shared vision for success for sustainability must be based on first order principles. These principles should be based on the outcome of sustainability not the transition to sustainability i.e sustainable development.

If the goal of a social system is to provide the opportunity for all to meet their needs, with all the complex balancing and judgment that such a responsibility involves, then interdependence, self-organisation and diversity are intrinsic and complementary components of robust and sustainable systems (Robèrt et al., 2004).

Within the perspective of robust and sustainable systems, Max-Neef defines Human Scale Development (as opposed to conventional paradigms of development and progress which are considered by many as a root cause of the global ecological crisis) as "focused and based on the satisfaction of fundamental human needs, on the generation of growing levels of self-reliance, and on the construction of organic articulations of people with nature and technology, of global processes with local activity, of the personal with the social, of planning with autonomy, and of civil society with the state." (Max-Neef et al, 1991:8) It is important to highlight here that “articulation” is understood as the construction of coherent and consistent relations of balanced interdependence among given elements. Development should be supported by the pillars of human needs, self-reliance, organic articulations and “sustained on a solid foundation which is the creation of those conditions where people are the protagonists in their future”. (Max-Neef et al, 1991:8)

The aim of Human Scale Development, or the path to a robust sustainable social system, is to move from the generation of satisfiers that are exogenous to civil society to the stimulation and creation of processes that arise from the bottom upwards.

This model contributes to understanding what is necessary for a paradigm shift that incorporates systemic principles. It also provides a useful
approach that meets the requirements of small group, community-based processes that have the effect of allowing deep reflection about one's individual and community situation, leading to critical awareness and, possibly, action at the local economic level, therefore influencing other parts of the bigger system.

It is obvious that a mining project causes significant social and environmental impacts at local, regional and even global scales, the most significantly impacted being the local community in the vicinity of the mining project. To be successful in contributing to a sustainable society a mining project should strive to maintain the ecological and social well being. The “success” of a mining project should be determined by its contribution to both human and ecosystem well being together. Miranda et al. (2005) state that “although some degree of disturbance is inevitable even in the best-managed mines, nearly all negative social and environmental impacts are avoidable if companies would operate according to the best possible standards.”

Currently the process of extracting metals and minerals from the lithosphere and utilising them in the technosphere is not completed within the boundaries of the four sustainability principles (Section 1.5.3), therefore contributing to non-sustainability. If a future vision of mining projects where the process\(^1\) of developing them is constrained within the four sustainability principles, thereby eliminating their contributions to non-sustainability, these projects will play an important role in progressing towards a sustainable society. Essential to building an effective strategy for the development of mining projects, a desired future must be outlined, giving something to backcast from.

Envisioning this future for mining projects within a sustainable society can be done by evaluating their development and operations using the FSSD as a lens. It can be said then that successful mining projects will have the following features:

---

\(^1\) The process of project development from the system perspective is one where material is extracted from the lithosphere and added to the biosphere, often resulting in contributions to natural systems and to the technosphere.
Mining projects….

- manage materials extracted from the lithosphere so they do not escape and systematically accumulate in nature (particular focus on sulphitic minerals, heavy metals and rare minor elements);
- select and manage fuels that do not contribute to systematic increases in greenhouse gases (GHGs) in the atmosphere;
- manage man made substances so they do not build up in nature;
- manage biodiversity so it is not systematically degraded;
- are designed so to include synergistic production systems where one organisation’s waste streams are another’s resources;
- are developed with participation from the local communities ensuring transparency, respect, accountability, self-organisation, diversity and interdependencies; and
- develop communities to ensure their economic independence from the project while adding value to social and ecological systems.

Hebertson (2003) has identified zones of stewardship over which a mining project has progressively less control but considerable influence:

1. Asset Stewardship covers the operations under the direct control of the company, the neighbouring communities and the local environment. Typically this is the mine operations itself and any associated beneficiation operations, transport and ancillary or infrastructure that is under its control;

2. Resource Stewardship covers the material inputs to the business, and therefore the operations of the company’s suppliers;

3. Regional Stewardship covers the socio-economic region the business is a part of and the associated natural environment;

4. Product Stewardship covers further processing of the company’s products by its customers, and the end use and disposal of the final consumer products. This is largely dependant upon the company’s involvement in the value chain directly. Solely
extraction mining companies will less influence over where the metal is sold versus a diversified materials company that provides ore to its down stream businesses; and

5. Global Stewardship covers the universal sustainability issues facing all companies and indeed all individuals in the global society.

3.2 Current Reality of Mine Project Development

3.2.1 A brief overview of mining

Society has extracted and used metals from the lithosphere since time immemorial e.g. the move from the Stone Age to the Bronze Age. The use of copper can be traced back to 7000BC. The principal classes of mineral commodities are:

- metalliferous minerals (including base metals, ferrous metals, precious metals, and minor metals);
- energy minerals;
- industrial and construction minerals; and
- diamonds and precious gems

Traditionally, minerals were most commonly produced near the deposits in which they are found or where they are predominantly used. However today the mining industry is a global one as relatively cheap transport; the need for the greater exploration and extraction of minerals and the opening up of many economies has resulted in the migration of the minerals industries to developing countries.

Ore is typically extracted from the earth’s crust in a number of ways depending on the geology, the type of ore body and the depth of the resource from the surface. Processes include, open cut, underground, strip mining and dredge mining.

The extracted ore is then crushed, washed and concentrated by various physical and chemical means. This is typically the end of the “mining” process. The concentrated ore then is transported to the refining and smelting operations where the ore is further purified into specific industrial grades for specific applications. Metals are then fabricated into different types of products demanded by society.
The ability of the metal to be recycled is dependant upon the metal retaining its chemical form in use. Steel (iron ore), lead, copper and aluminium maintain their basic properties and can be infinitely recycled and reused. However metals that are used in diffuse applications such as chemicals and pharmaceutical applications where they cannot be collected and recycled are hence lost to the use of society. Examples of common uses of mined products can be found in Appendix E. However in accordance with the First Law of Thermodynamics, these metals are not “lost” to the environment and exist within the ecosphere in unknown concentrations somewhere.

The availability of metals for recycling is also dependant upon the life of the product. Single use applications such as aluminium cans, and application with short term lives before becoming redundant such as personal computers, are readily recycled if they can be collected and extracted. However metal products with long lives such as railways, bridges, pipelines, and electricity distribution systems exist only as potential sources of metals to be recycled. The ability of metals to be infinitely recycled maintains the stock of metals in use in society. There is considerable recycling and reuse of metals occurring now. However, the increasing demands from the world’s rapidly expanding population coupled with inability to capture 100 per cent resulting in losses from the stock and dissipative uses will require new virgin metal to top up the societal metal in use.

3.2.2 An integral part of the economic system

Mining is basically an economic activity to create wealth from rocks. Mining companies are in business to create wealth for their shareholders from the extraction of ore which can be turned into valuable assets. The demand for new mining projects is driven from the demand for the products they produce i.e. metals. The value produced by the mining companies contributes to the Gross Domestic Product (GDP) of the host country as does the economic activity generated by the clean up of mine sites. The global mining industry returned a profit of US$67 billion in 2006 (PWC 2007) and employs 30 million direct employees or 1% of the global workforce and 300 million indirect employees (MMSD 2002). A considerable number of countries and communities depend on minerals production as a source of income and a means of development. Mining is
relevant in 51 developing countries – accounting for 15-50% of exports in 30 countries and 5-15% of exports in a further 18 countries, and being important domestically in 3 other countries. About 3.5 billion people live in these countries, with about 1.5 billion living on less than US$2 per day (MMSD Project, 2002).

The current demand for metals is booming. This is driven by the demand surge of Brazil, India and China due to rapid growth urbanisation and industrialisation. China’s economic growth for the last 5 years has been in excess of 10% per annum and its demand for minerals has doubled and almost tripled since the beginning of the decade. Rio Tinto, one of the major mining houses, reports that the commodity markets are entering their fifth straight year of growth for minerals and that the growing demand for base metals and projects that demand iron ore, aluminium and copper are expected to triple over the next 25 years. However supply growth continues to be constrained due to decades of under-investment in people, exploration resources mines and infrastructure. (Business Speculator 2008).

The mining industry is made up of a variety of companies with interests along the value chain. The mining exploration companies often known as “junior companies” are predominantly involved in the exploration and initial feasibility of the resource. Often their main objective is to find the resource. If the resource is feasible, this will attract the interest of the mid-tier miners and the major miners. The MMSD (2002) report identified that many of these “junior” companies are lacking in resources to deal with the social and environmental situations of their activities. There are about 40 large multinational companies which undertake activities along the value chain from mining through to refining, smelting and production. These mining companies are high profile and seek become a partner of choice for governments and local communities to develop the resource. However, the debate on the abundance of natural resources in some countries as being a curse or a blessing, since only a few of these countries have apparently succeeded in promoting socio and economic development (Resource Endowment Study², 2006), reinforces the questions of “how can a mining

² In May 2004, ICMM initiated its Resource Endowment initiative, a study to better understand how large scale mining activity in low and middle income countries can enhance the socioeconomic development of host countries, to identify lessons of experience, and define appropriate partnerships able to support governance improvements. The results to date demonstrate that non-renewable resources can be converted into other forms of capital (human, social, and physical) and trigger accelerated growth and poverty reduction.
project contribute to communities’ success?”, “what does success consist of?”, “how to shift from a ‘sustaining development’ perspective to ‘sustainable development’ strategy”?

3.2.3 Challenges faced by mining projects

The discovery, extraction and processing of mineral resources is widely regarded as one of the most environmentally and socially disruptive activities undertaken by business (Peck and Sinding 2003). The environmental and social impacts of operating mines have been widely described and are summarized in the Table 3.1.

Table 3.1 Environmental and Social Issues

<table>
<thead>
<tr>
<th>Environmental Issues</th>
<th>Social Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of biodiversity through destruction of habitats and essential ecological services</td>
<td>Loss of indigenous rights and access to traditional lands</td>
</tr>
<tr>
<td>Large volumes of waste rock</td>
<td>Large disparity between income levels of mine and non mine workers</td>
</tr>
<tr>
<td>Catastrophic consequences of tailing dams failure</td>
<td>Social tension and violence over land disputes, compensation</td>
</tr>
<tr>
<td>Dumping of tailings materials containing heavy metals to river systems and oceans</td>
<td>Influx of significant of migrants into the area looking for opportunities</td>
</tr>
<tr>
<td>Diffuse emissions of ore contaminants containing heavy metals to air water and soil</td>
<td>Health and social problems of alcoholism, drug abuse, violence</td>
</tr>
<tr>
<td>Production of greenhouse gases from reliance on fossil fuels for mining and infrastructure operations</td>
<td>Loss of ecological requirements such as access to clean water, traditional hunting grounds, cultural landforms</td>
</tr>
<tr>
<td>Leakage of toxic substances such as cyanide from ore processing facilities</td>
<td>Loss of traditional livelihood and cultures</td>
</tr>
<tr>
<td>Acid Mine Drainage</td>
<td>Displacement and relocation</td>
</tr>
<tr>
<td>Excessive use of water</td>
<td></td>
</tr>
<tr>
<td>Health related impacts from air &amp; water pollution</td>
<td></td>
</tr>
</tbody>
</table>

As a result of these large impacts, the mining and minerals industry has been facing some of the most difficult challenges of any industrial sector.
not only to obtain the so called ‘social license to operate’, but mainly to discover the ways to contribute to a sustainable society. The MMSD Project\textsuperscript{3} through various consultative mechanisms identified key challenges that represent the most pressing issues for the industry. Our interviews with industry representatives highlighted similar results, as summarized below:

**Viability of the Minerals Industry.** Since many of the large international publicly quoted mining and mineral companies state that they are committed to shareholder value, building the case for sustainability it is still a great challenge for the industry. Interviewees stated that often costs and time are limiting factors in the development of robust sustainability assessments and corresponding project design, because business objectives and sustainability benefits aren’t seen as different sides of the same coin. Hallstedt et al. (2008) also argue that there is a need to transition from a cost culture to the value culture, ensuring that sustainable development is well defined, understood by all levels in the organisations and integrated into business decision-making on a more disciplined and systematic basis.

**The Control, Use, and Management of Land.** Many problems and disagreement around issues such as compensation, resettlement, land claims of indigenous peoples, and protected areas are faced by mining projects since development of minerals unavoidably competes with other land uses. Often there is lack of planning or other frameworks to balance and manage possible uses, affecting the industry’s reputation on a global and local level and making access to land one of the most business pressing issues.

**National and Local Social and Economic Development.** The sustainability debate of mining is centred around the social and economic impacts of mining in exchange for the social and economic benefits of a project. The temporary nature of the mine has in the past led to the “boom and bust” cycles whereby a community or region has experienced the development gains whilst the mine is in existence, however after mine closure, the community has lost its source of employment and revenue and

\textsuperscript{3}In 2002 the International Institute for Environment and Development (IIED) published a comprehensive review of major issues facing the mining sector, a result of a two-year research project known as “Mining, Minerals and Sustainable Development” (MMSD). The report was commissioned by the World Business Council on Sustainable Development (WBCSD) and was sponsored and funded in large part by major mining companies.
is often left to deal with the problem of abandoned mines. In some cases the infrastructure that has been enabled as a result of the mining operations falls into disrepute through lack of maintenance and skills within the local community to utilise it once the support of the mining company has been withdrawn. Minerals have the potential to contribute to poverty alleviation and broader economic development. However, it needs to be planned and managed to ensure that it is invested for lasting benefits in support of national, regional, and local development.

**Environmental Management.** Although a great improvement over past practice has been made, and most major mining companies are committed to continuous progress on environmental performance, it is evident in the mining industry that there are considerable environmental impacts associated with most exploration, mining, and mineral processing. The challenge is in optimizing the trade-offs between environmental damage and the potential development benefits to local and national economies, ensuring that critical natural capital is maintained, that ecosystems are enhanced where possible, and that minerals wealth contributes to net environmental continuity. But the decision on where and how to apply resources in order achieve these objectives many times the greatest part of that challenge.

**Materials Stewardship.** The recognition that making progress on sustainable development requires greater attention to the management of the materials produced from mine exploration, through use to reuse, recovery, recycling and eventual disposal, and that metals should have optimal and appropriate use in society, number of challenges are posed to the industry, ranging from concerns about efficiency and waste minimization to the risks associated with the use of certain metals and substances. Interviewees articulated that materials stewardship is an emerging concern but there is still a lot to be done in order to become an industry practice.

**Access to Information.** The fact that mining industry is currently distrusted by many of its stakeholders and has been failing to convince them in many parts of the world of its potential positive contributions, companies struggle to manage:

- expectation that minerals development will be an engine of sustained economic growth;  
- expectation from local communities that the industry will provide
employment, infrastructure, and other benefits that counter the risks and impacts they experience and will leave them better off than when the project started;

- expectations from employees regarding safer and healthier working conditions and a better community life;
- expectations from environmental organisations for a much higher standard of performance and that the industry will avoid ecologically and culturally sensitive areas;
- expectations from investors regarding higher returns and financial results; and finally;
- expectations from consumers in respect to safe products produced in a manner that meets acceptable environmental and social standards (MMSD Project, 2002).

Trust can be considered as an important aspect of robust social fabric that has been declining in society (O’Neill 2002). Understanding that processes by which information is generated and communicated play a key role in building or undermining trust, ensuring access to information become a great challenge to the industry in order to build trust, cooperation and improve all players’ ability to negotiate effectively.

3.2.4 Current definition of success for mining projects

Mining history is filled with legacies of abandoned mines, damaged ecological systems and disrupted communities. The Oxfam Mining Ombudsman and the IFC Ombudsman, continue to investigate, report and monitor complaints in the mining industry related to human rights and environmental violations, particularly in the developing world where the legislation and governance structures are significantly less than those in developed countries. History shows that although there has been significant contribution to the economic development of the host country, mining in general has not been successful in its contribution to ecological and social sustainability.

Our studies have shown that the success of the mining project is typically judged on its ability to provide the required ore at the least cost within environmental licensing regulations and with minimal complaint from the local community. The current mining boom is pushing to achieve
production in shorter and shorter timeframes to beat the competition to market and maximise return to shareholders. The legislative system drives the behaviour of compliance with allowable pollution standards, loss of biodiversity and acceptability of disruption of local communities in return for economic development. Generally the negative social and ecological impacts are “traded off” for the economic advantages brought by the mining project. The impact assessment process has recognised that that a mining project will invariably change the ecological and social fabric of the region but the emphasis is on “doing less harm”. Typically the reward and recognition system for mining projects is based on achievement of short term goals such as projects achieving schedule and budget requirements. More progressive companies also have a key “at risk” component of their reward systems which incorporates aspects of leading and lag indicators for environmental health & safety and community performance. Typical examples of current success for mining project phases are outlined in the box below:

<table>
<thead>
<tr>
<th>Exploration:</th>
<th>Identify and prove feasible deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site design:</td>
<td>Most cost effective mine site design in accordance with legislative requirements &amp; minimisation of societal impacts</td>
</tr>
<tr>
<td>Design for Post Mine Closure:</td>
<td>Providing on going viability for the community once the operations have ceased</td>
</tr>
<tr>
<td>Operations –</td>
<td>Operate the mine to minimise environmental and social impacts to maximise economic return.</td>
</tr>
<tr>
<td>Closure –</td>
<td>Close the mine with minimal negative impacts and leave a positive legacy</td>
</tr>
</tbody>
</table>

The mining industry has recognised that in order to achieve and maintain its licence to operate, it must also achieve its “Social licence” to operate. There have been a number of studies and reports such as:

MMSD Sustainability Report 2002, World Bank Extractive Industries Report Minerals council of Australia – Enduring Value, ICMM Best Practices which provided detailed guidance to the mining industry on how contribute to sustainable development. Most of these reports utilize and refer to the Brundtland Commission (WCED 1987) where Sustainable
Development is defined as the one that:

"... meets the needs of the present without compromising the ability of future generations to meet their own needs."

This definition encompasses the need to incorporate environmental, economic and social considerations into decision-making; fosters intra generational equity through the elimination of poverty by concentrating the benefits of development in lesser developed areas and to ensure that inter-generational equity exists.

The ICMM has identified 10 Principles for sustainable development that are based on the issues identified in the MMSD Project referred to earlier. These 10 Principles are shown in the Table 3.2 below:

<table>
<thead>
<tr>
<th></th>
<th>ICMM Principles for Sustainable Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement and maintain ethical business practices and sound systems of corporate governance.</td>
</tr>
<tr>
<td>2</td>
<td>Integrate sustainable development considerations within the corporate decision-making process.</td>
</tr>
<tr>
<td>3</td>
<td>Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.</td>
</tr>
<tr>
<td>4</td>
<td>Implement risk management strategies based on valid data and sound science.</td>
</tr>
<tr>
<td>5</td>
<td>Seek continual improvement of our health and safety performance.</td>
</tr>
<tr>
<td>6</td>
<td>Seek continual improvement of our environmental performance.</td>
</tr>
<tr>
<td>7</td>
<td>Contribute to conservation of biodiversity and integrated approaches to land use planning.</td>
</tr>
<tr>
<td>8</td>
<td>Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.</td>
</tr>
<tr>
<td>9</td>
<td>Contribute to the social, economic and institutional development of the communities in which we operate.</td>
</tr>
<tr>
<td>10</td>
<td>Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.</td>
</tr>
</tbody>
</table>

It should be noted that these principles cover the members of the ICMM which are 16 of the world’s major mining companies and 28 Industry
Associations\(^4\) and hence there are a number of mining companies which do not subscribe to these principles. Sethi (2006) criticises these principles as not being specific enough, considering the issues only from an industry-centric view, focusing on continual improvement and limited specificity on what “sustainable development considerations” actually entails.

Most of the mining industry studies mentioned provide guidance on how to deal with specific aspects or issues relating to mining, however they do not provide basic principles for achieving sustainability. This lack of understanding of success was evident with company and industry interviews as some of the impediments to contributing to sustainability included: lack of understanding what sustainability is, lack of time to implement sustainability initiatives due to time constraints and an inability to incorporate sustainability considerations into every day business decisions. Similar results also found in Hallstedt et al. (2008) referring to non-mining organisations.

Mining companies have recognised the need for sustainable development and there is an emphasis on becoming “partner of choice”. This entails mining companies developing their projects such that the communities “are sorry when they leave and welcome them back” as the community has enjoyed a positive experience from the presence of the mining companies through development opportunities, rehabilitated ecosystems, capacity building, and enhancement of their social fabric.

The projects that have been identified as being successful (see for example Harvey & Nish 2005), Gibson 2005, ICMM Best Practice case studies) have suggested the following aspects as being significant contributions to success:

- Mutual rights and responsibilities
- Capacity building in mining and non-mining related occupations
- Creating a shared vision for regional development
- Strong and visionary partnerships
- Transparent calculation of financial benefits
- Quick win visible projects
- Involvement and capacity of marginalised sectors of the community

3.2.5 Current Strategies and Actions

The definition of success for sustainability efforts in the mining industry is currently defined and guided by several high-level frameworks which in turn inform the strategy level. These frameworks outline principles for success and concepts on which to build corporate and project strategies for sustainability. Examples of well-known and used frameworks in the mining industry today are the ICMM Sustainable Development Framework, UN Global Compact and the IFC Guidelines and related Equator Principles. In addition to frameworks, concepts such as Eco-efficiency, Carbon Neutrality and Zero Fatalities guide planning and strategy building.

A strategy is a plan and associated methods for obtaining a specific goal or result. Focus on broad high-level ideas provides the foundation for strategies within the mining industry. Examples of such ideas are:

- Dematerialization
- Substitution
- Detoxification
- Materials stewardship
- Equity
- Diversity

They represent fundamental ideas which underpin the concepts and frameworks reported in the success level and guide strategy building to reach a specific goal. The material contained in the remainder of this section is not intended to be an exhaustive list of strategies initiated and used in the mining industry but a collection of examples of the current reality as identified during our studies.

Dematerialisation strategies support the reduction or complete avoidance of products or services used by the mining industry in their operations. Often linked to ‘eco-efficiency’, dematerialisation makes good business sense. Multinational mining company, Anglo American realised US$583 million in cost savings and efficiencies, partly due to focusing on dematerialisation of their water and energy use in operations (Anglo American SD report 2007).

Closely related to dematerialisation are substitution strategies. One of the most pressing issues around substitution is the need to find alternatives to fossil fuels for energy and transport uses in the mining industry. Recently BHP Billiton published a case study indicating they were working with
Caterpillar, their major supplier of earthmoving equipment. Within this study, Caterpillar and BHP were assessing the potential of using alternative fuels for their off-road mining equipment on a global scale by 2020. BHP states, “Key drivers for considering alternative fuels are energy security, possible cost savings and reductions in hydrocarbon emissions. It is estimated that using biodiesel, for example, could reduce vehicle greenhouse gas emissions by up to 80 per cent” (BHP Case Study 2007). Another example of substitution of fossil fuels for alternative energy sources is highlighted in a press release from the large gold producer, Barrick. The July 11, 2007 release highlights several initiatives in alternative energy development for Barrick’s operations including:

- A US$40 million, 10 turbine, 20 megawatt wind farm, located in the Punta Colorada area of Chile;
- 2 megawatt demonstration wind turbine near its Veladero mine in San Juan, Argentina;
- construction of 1 megawatt solar energy farm adjacent to its 115 megawatt natural gas generating station in Nevada, USA; and,
- a US $28 million project to bring electricity to parts of the remote Mara region of Tanzania largely through hydroelectric power stations.

Often, the themes of dematerialisation, substitution and detoxification can be used in combination, realizing a multi-dimensional benefit. In 2010 the Mexican mining company Peñoles could be using a unique, more environmentally-friendly method for extracting gold and silver from ore using a process which involves thyourea. Thyourea, a molecular compound similar to urea from decomposing plants, whose oxidation would be controlled by electricity, could eliminate the use of cyanide to precipitate gold and silver from ore, and be used indefinitely (WBCSD 2008). By substituting thyourea for cyanide, this example could contribute to dematerialisation as well as indirect detoxification. By eliminating the use of cyanide in processing, the need for detoxifying water mixed with cyanide would be avoided.

Materials stewardship strategy within the mining industry has seen incredible focus over the last 10 years, resulting in much sound science, deeper understanding of material life cycles and how to effectively capture materials mined from the earth in tighter and tighter technical loops. A multi-phased cycle, encompassing process stewardship as well as product
stewardship, continued research and development into all phases continues. Canadian mining major, Teck Cominco Limited realises certain aspects of materials stewardship through strategies based on using their metallurgical operations based in Trail, British Columbia, Canada.

“We have been engaged in the recycling of lead-acid batteries for many years at our Trail metallurgical operations. In 2007 we continued our work to expand the recycling business in Trail to include processing of electronic scrap. Over 4,300 tonnes of electronic waste were recycled through the smelter in 2007. Our goal is to treat 8,000 tonnes in 2008. Through these initiatives, we advanced our sustainability performance in 2007 related to resource stewardship and life-cycle management of metals while identifying potential new sources of “urban ore” to supply our processing and refining facilities.”

(Teck Cominco Limited Annual Report 2007)

Facilitating strategies also exist in the strategy portfolios of many mining companies, examples of which include stakeholder engagement, community development, risk management, equity and biodiversity strategies.

Stakeholder engagement and community development strategies are currently focused on maintaining the ‘social license to operate’. Companies like Anglo American recognize the need for stakeholder engagement, especially with communities affected by company projects. Chairman Sir Mark Moody-Stewart states, “Communities across the world have become a great deal more assertive and empowered…..to operate we need the consent of the people who live in the vicinity of a new mine. To ignore them [the communities] risks delay and reputation damage and is a breach of our principles.” Anglo American has spent considerable time and effort on their stakeholder strategies as evidenced by their advanced stakeholder engagement tool called “SEAT5”, now in its second edition.

Teck Cominco, a Vancouver based company with operations in Alaska, effectively used stakeholder strategies to collaborate with traditional subsistence hunters and learn from their advice on the environment. The native people of the region have lived there for more than 10,000 years and

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5 Although this tool has been developed internally, Anglo American has publicly released the first version of their tool
contributed their knowledge about their traditional way of life, local cultural and social priorities. (Teck Cominco SD Report 2006). In collaboration with the company, formed an advisory committee as a stand-alone body that continually advises Teck Cominco on issues such as the physical, cultural, social and economic needs of the traditional people of the area. Closing access roads for caribou migration, respecting hunting and fishing seasons in mine operation schedules and continually testing and communicating about air, land and water quality are examples of ongoing collaboration that exists.

Community development strategies within the mining industry currently approach these projects with the mindset that communities must not have a long-term economic reliance on the mine, ensuring that when the life of the mine is exhausted, the local communities will not collapse. Ensuring this is done with transparency and in collaboration the community is necessary for successful development. Several of these themes also translate into key drivers for corporate risk management strategies. Vale, a Brazilian company with operations worldwide, states, “Some of the benefits generated in the implementation of the corporate process of risk management, with a wider approach, are increased transparency, better communication among the business units, assistance in financial hedging decisions, and valuation of the impact of adverse scenarios on the company’s performance.” (Vale Sustainability Report 2006).

Linked to corporate risk management strategies and stakeholder engagement are strategies around equity and how to use mineral endowments to support sustainable development efforts. The ICMM’s “Resource Endowment Initiative” states, “The “resource curse” thesis continues to dominate attitudes towards the private mining and minerals sector. Yet mining investments in some poor countries have generated considerable economic benefits….Using objective analytical tools, the results to date demonstrate that non-renewable resources can be converted into other forms of capital (human, social, and physical) and trigger accelerated growth and poverty reduction.” (ICMM Website 2008). To support this strategy, the ICMM has developed an analytical framework and recently published several country-specific case studies for Chile, Ghana, Peru and Tanzania.

Biodiversity is the basis of innumerable environmental services that keep us and the natural environment alive – from the provision of clean water and watershed services to the recycling of nutrients and pollination (ICMM
Mining processes disturb, disrupt and damage biodiversity in the areas in which projects operate and as a result, many companies place high priority on understanding their impacts and finding solutions. Pressure from country-specific mining associations also strengthens the need for biodiversity strategies. An example from Canada reads, “The Mining Association of Canada (MAC) today [July 11, 2007] released a *Mining and Biodiversity Policy Framework* outlining its member company commitments with respect to biodiversity conservation and sustainable development.” Rio Tinto understands the need for biodiversity strategies and says, “Our strategy states that we aim to have a net positive impact (NPI) on biodiversity. We, therefore, need to demonstrate that our actions have positive effects that outweigh the inevitable negative effects of the physical disturbances and changes of land associated with mining” (RioTinto website 2008).

Strategies, informed by the principles of success for sustainable development, guide companies in their development process for mining projects, from exploration to mine closure and restoration. Strategies can also be informed by the information gathered during the completion of tools. One example of a tool helping to inform strategies can be seen when companies complete social and environmental baseline studies in impact assessments. Often information from these studies is used during the engagement process with communities, either in series of public hearings and throughout the collaboration process. From these relevant sustainable development strategies, actions for achieving the goals of each strategy are prioritized and implemented. Although each strategy by itself is important, collaboration and communication between different teams responsible for each strategy within a project is essential to success from a whole systems perspective.

### 3.2.6 Current Tools

The mining industry has many tools which it has developed in support of strategies and actions for achieving certain goals within sustainable development (see Appendix F). Many of these tools are very discipline specific, which prove to be useful in collecting data, monitoring actions implemented (guided by strategies for success), and are used in the reporting process. The information gathered through the use of tools provides rich material for company reports, documentation, applications for
finance and licensing, and transparency initiatives to stakeholders. Tools can sometimes have specific project stages in which they are the most appropriate to apply in order to collect the relevant data required during a certain phase of a project’s development timeline.

Although these highly developed and specialized tools are useful and provide essential functions during the development of a mining project, these attributes can also prove to be a hindrance from a systems perspective. Since tools can be very discipline specific, they lack the ability to consider the interconnectedness of all of the disciplines within a mining project, thereby missing an opportunity to inform each other’s area of specialty.

Often tools are not connected to a definition of success or an overall strategy to achieve success and may be positioned within the project development at a stage where any information that could have been used to strategically plan was needed earlier than the actual application of the tool (Byggeth et al. 2006). When tools are not linked to overall strategies, which give them context, they can engender a ‘tick and flick’ mentality. Tools applied with this mentality are at risk of losing their ability to contribute to actions or strategies and succumb to being an exercise in completion.

An opportunity exists for tools to be developed within the context of the four principles for sustainability and inform higher levels of strategic planning i.e. system level and success level. Tools with these boundaries and added context might prove to be inherently more useful to strategies and provide inspirational material to be shared across disciplines, informing all levels of development of mining projects so that they contribute value, innovation and do not undermine the robust nature of the social and ecological systems they are evaluating.
4 Discussion

The mining industry has recognized that its development of new mining projects and its contribution to local, regional and global society must change. It recognises the business case for sustainability actions is real in terms of obtaining a continued licence to operate, access to new resources, increased industry reputation and attraction and retention of skilled employees. Thus in the last decade, the mining industry has focused its attention on minimizing the environmental impact of each operation and developing local capacity to reap the economic benefits of the presence of the mine in the region. In particular there has been a major body of work studying how to reduce the dependency of the local community on the temporary operations of the mining project and enable the community to flourish once the mining operations have ceased. To assist this approach, the mining associations such as the ICMM, lending bodies such as the IFC & World Bank and individual companies have completed studies of the mining industry challenges and issued guidance materials and tools to implement sustainable development.

4.1 Assessing the System

A primary method for understanding the system used for mining projects is conducting an impact assessment. Although this process varies throughout the world, it is generally one of identifying the environmental, social and health impacts associated with the mine project against baseline studies and determining if these impacts can be mitigated to an acceptable level. Since many companies rely only on the Environmental Impact Assessment (EIA) in order to “understand the system” and the potential consequences of interfering in this system, it is important to observe: how these studies define the boundaries of the system; what are the underlying strategies to avoid, reduce and compensate impacts; to which extent a clear definition of success supports the strategies; and what are the opportunities of an EIA in influencing project design.

It is usually at the stage where the company has decided to go ahead with the operation that the regulatory Environmental Impact Assessment (EIA) is required to be undertaken. An Environmental Impact Assessments may be undertaken voluntarily (to assist the developers to understand the
impacts they will be required to mitigate/manage) or as a formal approval process to achieve financing (World Bank 1999) or obtain governmental approvals.

Within mining projects the EIA is typically completed during the feasibility stage and is undertaken as part of the requirements to obtain the permit to commence construction and operation. Typically in an EIA process, baseline ecological, environmental and social data is collected and then the effects of the mining operation are predicted to estimate the extent of the change (positive or negative) as a result of the mining operations. The proponent is required to advance mitigation strategies to minimise any negative impacts. The extent of stakeholder involvement and consultation varies considerably in each jurisdiction. The acceptance of the EIA and mitigation strategies is usually undertaken by the relevant government authority which will then issue the required development/operational permits which may be accompanied with a set of "conditions" which the proponent is legally bound to implement. The types of conditions typically include operational design changes as described by Gibson (2006).

There has been considerable debate and criticism on the effectiveness of the EIA as predictions modelled in the EIA are not compared to the actual operating parameters on completion. The timing of the EIA may be too late in the design process to alter significant parameters and that the EIA is seen as a red tape exercise to obtain the permits rather than a value-add to significantly alter operational conditions to enhance sustainability.

EIAs are now being expanded to consider "sustainability" aspects of projects in particular the economic and social considerations. These are integrated Triple Bottom Line approaches, however Gibson (2005) recognises that this "pillar" approach has maintained the categorisation and separation of the issues rather than integrated thinking required for sustainability. Pope et al. (2004) believes that these types of assessments typify a ‘reductionist’ approach to sustainability and dividing the holistic concept of sustainability into three pillars runs the risk of the sum of the parts being less than the sum of the whole. Additionally they argue that assessment for sustainability requires a clear definition of sustainability and corresponding criteria against which the assessment can be conducted. Gibson (2005) recognises that if environmental assessment is to be transformed into sustainability assessment, some shared agreement on the fundamentals of sustainability is needed.
The most critical issue with respect to sustainability assessment is how environmental, social and economic information is analysed, integrated and presented to decision makers. A robust, adaptive and transparent approach based on sound principles is required. Gibson (2000) states that “for practical assessment purposes especially at the project level, it is usually desirable and often crucial to specify the sustainability principles, objectives and criteria as fully and as credibly as possible before proponents begin thinking about their purposes and options”.

4.2 Defining Sustainability

The majority of the work related to sustainable development in the mining industry has been based on the definition of sustainable development as defined by the Brundtland Commission (WCED 1987). In a recent conference, Globe 2008, held in Vancouver Canada, plenary and session speakers advised that the time for debating the definition of sustainability/sustainable development had passed, and the time for action was imperative. Whilst recognizing that concrete action is urgent, at many of the sessions concern was raised that the lack of a clear definition of sustainability was hampering efforts to take these required action. This was particularly evident at the Prospectors and Developers Association Canada (PDAC) workshop formulated to discuss the “Sustainable Development Frameworks - Principles and Guidelines for Responsible Exploration” which recognised that the overall lack of understanding of how to define sustainability was hampering efforts. The Brundtland Commission’s definition of sustainability is an eloquent vision of development without compromising future generations, however it has also been widely criticized. Criticisms include, but certainly not limited to:

- Does not give adequate attention to the biophysical limits on which society operates (Porritt 2007)
- Does not question the ideology of economic growth, challenge the consumer culture and is too human-centric (Lele 1991)
- Reflects a philosophical and political view rather the unambiguous scientific view (Mebratu 1998)

The difficulties of defining sustainability and sustainable development have been well documented (Gibson 2005, Porritt 2007, Medvečka & Bangerter unpublished, Robørt et al 2004). Porritt (2007) states sustainability as the
capacity for continuance into the long term future and sustainable development is the process by which we move towards sustainability.

From the FSSD approach, the Brundtland definition provides an elegant vision of the future yet it lacks robust first order principles that must be met as a minimum to achieve the overall goal of sustainability. Hence the Brundtland definition is not “backcastable” to enable planning for a future constrained by science-based, first order principles.

The ICMM principles are predominantly strategies on how to achieve sustainability, but without a robust definition of success, it cannot be determined if the actions resulting from these strategies, actually lead to sustainability. When analysed through the lens of the FSSD, the ICMM principles greatest contribution is to the levels of Strategy, Actions and Tools. Basing sustainable development initiatives on only these principles is like treating a chronic headache with only a few aspirin, not addressing the root cause of the headache. Combining the ICMM principles with a science-based definition of global ecological and social constraints for success would add value and provide context, and therefore overall direction, for sustainability.

4.3 Providing clarity on Sustainability Principles for the mining industry

Our study demonstrated that the four Sustainability Principles (SPs) have not typically been used in the mining industry largely due to misinterpretations of SP1. Often the first Sustainability Principle is interpreted as being “not relevant (or not applicable) to the mining industry” because the business of a mining company is to bring the metals from the lithosphere to the technosphere. However, as Chad Park (TNS Canada) notes in an address to the Canadian House of Commons Environment and Sustainable Development Committee (2008), the First Sustainability Principle does not say that there is “no mining” in a sustainable society. But that whatever materials that are used from the Earth’s crust, must be used in a way that prevents their accumulation in natural systems. For the mining industry this means that the materials that are extracted are used in a way that they are not lost from the system, that the lithospheric contaminants liberated during the mining process are managed in such way that they cannot enter natural systems, and the
reliance on fossil fuels is minimised.

The following table attempts to describe these principles for sustainability with relevance to the mining industry.

**Table 4.1 Principles for Sustainability**

<table>
<thead>
<tr>
<th><strong>Sustainability Principle 1</strong></th>
<th>Systematic concentration rises are a strong indication that nature’s powerful regenerative capacities have been exceeded. Aligning with SP1 can involve substituting minerals that are scarce in nature with others that are more abundant, using all mined materials efficiently, reducing dependence on fossil fuels and managing problematic elements in closed loop systems rather than by ‘dilute and disperse’ strategies. It does not mean “no mining”, but it does mean that companies engaged in mining or dependant on mined materials have an obligation to avoid dispersion and systematic build up of substances from the earth’s crust in the biosphere.</th>
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<tbody>
<tr>
<td><strong>Sustainability Principle 2</strong></td>
<td>SP2 addresses the use of substances produced industrially that are foreign to nature. Alignment with SP2 can involve substituting certain persistent and compounds foreign to nature with ones that are normally abundant or break down more easily in nature, using all substances produced by society efficiently, and managing potentially toxic chemicals in closed systems to avoid dispersion.</td>
</tr>
<tr>
<td><strong>Sustainability Principle 3</strong></td>
<td>SP3 is concerned with the physical protection of natural habitats and biodiversity, which underpin the robustness of the regenerative services we depend on from nature. Avoiding long term degradation of nature means drawing on resources from well-managed ecosystems, systematically pursuing the most productive and efficient use both of those resources and land, and exercising caution in all kinds of modification of nature.</td>
</tr>
<tr>
<td><strong>Sustainability Principle 4</strong></td>
<td>SP4 is about avoiding the economic, social and political conditions which undermine the foundations of human well-being and social coherence. This means checking whether our behaviour has consequences for people, now or in the future, that restrict their opportunities to lead a fulfilling life. This includes asking ourselves whether we would like be subjected to the conditions we create. (also referenced as the Golden Rule).</td>
</tr>
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</table>

( Herbertson 2005)
4.4 Recognising the need to shift business models

The focus of the mining industry on compliance and risk minimisation has resulted in continuous improvement and eco-efficiency, however this does not encourage break-through thinking, whole system design and innovation. Pursuing best practices in isolation of a compelling vision of sustainability is an illusion that will not necessarily lead to sustainability. Environmental and social risk management approaches are still seen as compliance driven with the emphasis being on the sustainability of the business rather than its contribution to societal sustainability. Although acquiring the so called “social licence to operate” represents great improvement compared to past practices, since it implies the need for social participation in the development of any activity, the potential of stakeholder dialogue to influence business and project design decisions is commonly poorly managed, transforming participation in one of the requisites of a compliance checklist. The emphasis on compliance manifests as a standard to be reached rather than envisaging a goal to be aspired to.

The business model for mining companies is typically one of shareholder value and pursuing sustainable development as a strategy for achieving this success. This is a different model to defining success for company within the constraints of achieving sustainability. The uptake of sustainability approaches in the mining industry is wide and varied.

![Five Stage Sustainability Journey](adapted from Willard 2005)

**Figure 4.1 Five Stage Sustainability Journey (adapted from Willard 2005)**
Companies in a pre-compliance and compliance stage can feel no obligation to anything beyond profits and/or manage their liabilities by obeying the law and operating within their regulated or legal obligations. The circle in the figure above represents the business model. During these two stages, an additional circle which would represent sustainability is either non-existent or it is considered to be completely separate, adding no value to the business model. Businesses at Stage 3 represent companies that are aware of their reputation, risks to it and have possibly had a public relations crisis to move them from stage two to stage three. Stage 3 companies also have begun to understand that being proactive with initiatives that save the company expenses through efficiencies in operations and cleaner productions makes good business sense. Beginning to merge sustainability with the business model, specialized teams often work isolated from each other, presenting a challenge when trying to move sustainability ideas across team boundaries. Stage 4 and 5 companies have succeeded in integrating the business model within constraints for sustainability and have institutionalized initiatives that contribute value and innovation to all stakeholders. The difference between Stage 4 and Stage 5 companies is found when examining their means and ends. A stage four company has transformed itself, contributes to a better world and enjoys business success and competitive advantage through sustainability initiatives. A Stage 5 company began with a values-based commitment to the continued well-being of societies and ecological services, therefore making it a successful business (Willard 2005).

The mining industry comprises a wide variety of business and hence their business models represent the spectrum from the Stage 1 (pre-compliance) to Stage 3 (Beyond compliance). Our research showed that although there are some excellent case studies of sustainability initiatives exhibiting Stage 4 attributes that have been implemented in various aspects of mining projects such as eco-efficiencies and community development, it is predominantly driven from the prospect of risk minimization. While the examples of companies with sustainability initiatives in Stage 4 is slowly growing, it is not an industry norm.
4.5 Leadership, leadership and more leadership needed

Doplett (2000) has identified seven blunders of implementing sustainability. These include:

<table>
<thead>
<tr>
<th></th>
<th>1. Patriarchal thinking</th>
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<td></td>
<td>2. Silo approach</td>
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<td>---</td>
<td>------------------------------------------------</td>
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<td></td>
<td>3. No vision of success</td>
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<td>4. Confusion over cause and effect</td>
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<td></td>
<td>5. Lack of information</td>
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<td></td>
<td>6. Insufficient mechanisms for learning</td>
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<td>---</td>
<td>------------------------------------------------</td>
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<td></td>
<td>7. Failure to institutionalise sustainability</td>
</tr>
</tbody>
</table>

In order to effectively reduce the amount and frequency of the above mentioned blunders, a mechanism through which the amount of empowered leaders within project teams and corporate cultures must be found and exploited. The successful mining project that contributes to sustainability needs leaders at every level of the mining project, local community and stakeholders.

Mining projects have typically seen themselves as the patriarch of the local community – where, in return for the rights to mineral resource, there is a transactional activity of providing services to the community, often without adequate consultation with what the community wants or can sustain, ignoring cultural specificities and local knowledge, thus creating an economic and social dependence on the mine. Such an approach needs to change to a model of the mining project being a stakeholder in the community development process rather than being at the centre of the development. A company centric mindset can result in dependence by stakeholders on the project and the delegation of responsibilities by the government to the mining company.

This change in mindset is illustrated in Figure 4.2 below:
Providing an organization which embraces and encourages learning is necessary to encourage innovation and creativity. Stakeholders need to be empowered with “psychological safety” to experiment and take risks to achieve the desired future.

The provision of information is a necessary enabler of change and innovation. Thus members of the project team and stakeholders need access to the available knowledge of the system and the overall vision is required to enable decisions to be made in line with the vision. Similarly, the lack of information to the community and stakeholders with respect to the mine, its impacts and opportunities has resulted in conflict.

A silo approach is typical in mining projects whereby the environment department is typically focused on the compliance with the licence, Impact Assessment and government requirements, whilst the community department is dealing with local community complaints and minimizing social risk to the project. However, there is not a common definition of success for sustainability to which all departments are striving and can connect with. The organizational structures within mining projects do not enhance an interdependent approach to sustainability. Generally, sustainability responsibilities are within departments responsible for environmental/health & safety (often these are combined), and community affairs. Sustainability can also rest with corporate/external affairs and with the emphasis on climate change, often this is a departmental responsibility which may be coupled with sustainability. The structure of having different aspects of sustainability within the responsibility of different departments is not in itself a problem – however, the lack of understanding and a common mindset to sustainability can lead to different interpretations, competing...
agendas and resource allocation between the departments and potential trade-offs.

If many of the ‘blunders’ of sustainability are in part contributed to by a need for more leaders, it can be said that sustainability needs to be led by the corporate level, communicated through sustainability reports and policy statements. This information must be encouraged and multiplied in all levels of the company. Consideration of the four sustainability principles must be evident, and thus become institutionalised into every decision that a mining project makes – from the decision to mine in a specific location to where the food is sourced for the project.

4.6 A new question for a mine project

In order to enhance the long-term economic value of the ore body and the return to shareholders, the first question that a mining company should ask itself is:

How can this mining project contribute to local, regional and global sustainable development in the context of the principles for sustainability?

People innately respond positively to knowing they are helping to create a better world and feel better about the work they are doing. With such a question to be answered, there is the opportunity for breakthrough innovation and creativity to deal with the systemic causes of problems rather focusing on minimizing symptoms such as environmental pollution or community unrest and dissatisfaction with the miners’ performance. If there is not a compelling and overwhelming YES to this – perhaps the overall feasibility of the mine itself should be questioned.
5 Recommendations

The following recommendations are provided for members of Mining Project Teams. As there are many actors involved in the mining project from exploration to mine design, operation and post closure, the recommendations provide general guidance in accordance with the Framework for Strategic Sustainable Development. Figure 5.1 below provides an overview to apply the FSSD to a project. Each element is described in more detail in the following sections.

![Diagram of Applying the FSSD to a Mining Project]

*Figure 5.1 Overview of applying the FSSD to a mining project*
5.1 Understanding the system in which the mining project operates

As discussed earlier in this thesis, a mining project has five zones of stewardship. These zones are asset, resource, regional, product and global zones of stewardship. A mining project has most control over its assets and resource i.e. its operations and supply chain, however it has considerable influence over its impact on the social, ecological and economic aspects of the region in which it operates. Thus it is in these areas of influence that the mining project needs to ensure the greatest value is achieved with minimal impact. The product stewardship zone is predominately further down the value chain and was not covered in the scope of this thesis.

In order to understand how a mining project can add value to society whilst operating without the systematic degradation of life supporting resources, an understanding of the social and ecological system in which the mining project exists is required. Typically the information on the overall ecological and social systems obtained at the commencement of exploration is sparse – information focuses on the geology and feasibility of the ore body obtained by non-interconnected specialists in each discipline. The Environmental and Social Impact Statements which provide extensive information are not usually conducted until the feasibility of the ore body has been determined.

A process for better understanding the local, regional and global systems and the interdependencies should commence prior to the start of exploration and should be an ongoing process throughout the mine project development. A deep understanding of how the project fits within the overall system provides opportunities to identify potential impacts, improvements in project design as well as consider opportunities for value creation. Since sustainability is a ‘system problem’, it requires ‘system solutions’. A multi-disciplinary approach is implicit in whole systems thinking, allowing new perspectives and stimulating the innovative process further across traditional boundaries (Herbertson 2005).

Gathering ecological and social information will enable the first contact with the local community, who generally represent the most impacted people as a result of the project. It is common knowledge within the mining industry that the probability of projects in the exploration phase progressing
to development of an operational mine are low. At early stages of exploration, there is the potential for a “pseudo-mine” where the local community expects a fully operational mine prior to the feasibility of the ore body being determined. Studies, interviews, literature and history have shown that this first encounter with the local community is often where trust is gained or lost between the project team and the community. It is at this stage that false expectations can build. Therefore making sure this first contact is done with ample transparent information on the company’s processes is essential for a healthy basis for the ongoing relationship, whether the development progresses or the exploration ceases. The earlier this is undertaken, the less likely there is to be misunderstanding of the project and the potential impacts or benefits.

Community members are an integral part of a mining project and should have opportunities to provide their knowledge of the system in addition to “specialist” knowledge from scientific disciplines. If the goal of a sustainable system is to provide the opportunity for all to meet their needs, for present and future generations, a mining project as part of this system should engage affected communities. A process of regular dialogue should be initiated to identify current deprivations and potentialities regarding human needs and in what ways the project could contribute to undermining or enhancing the community’s opportunities for realizing needs. Mining projects have the challenge to understand at a deeper level the local dynamics of realizing needs in order to design projects that contribute to the construction of coherent and consistent relations of balanced interdependence among the project, communities and nature.

Free prior informed consent (FPIC) refers to the right of a local community to be informed about mining operations on a full and timely basis and to approve a mining operation prior to the commencement of operation (Environment Law Institute 2004). This concept is being enshrined in some legislation in mining countries and some companies such as Rio Tinto have incorporated it into their decision making processes. This is a move away from having the exploration imposed upon them to being a willing and active participant in the mining project. This approach also gives local communities the right to reject a mining project. Understanding the system and the boundaries in which the potential mining project may occur, will equip communities to exercise their free, prior and informed consent and be the protagonists in their future, through acceptance or rejection of mining project proposals or by determining specific requirements for the design
and operation of the project.

Considering that any development initiative aiming the satisfaction of fundamental human needs cannot be structured and conducted from the top downwards, be imposed by law or decree, a mining project should consider community development processes that only emanate directly from the actions, expectations and creative and critical awareness of the protagonists themselves (Max-Neef et al, 1991). Therefore a true participatory approach, comprising the attributes of openness, cooperation, transparency, inclusiveness and involvement (Benhaim et al 2008), is required to identify the information necessary to understand the system in which the mining project will operate. This will enhance buy-in, provide deeper knowledge of the system and enhance a mining project’s social licence to operate.

Obtaining information about the system is time consuming and adequate time for the collection and understanding should be provided for in the project schedule. To understand the system, the following information could be gathered within this approach:

- Ecological services upon which the project and stakeholders rely;
- Communities’ self-diagnosis around needs and satisfiers: identification of deprivations and potentialities, the “destroyers” that impede the actualization of fundamental needs and the requirements for the desired community where needs are fulfilled;
- Stories of the local communities in relation to the land, culture and heritage and the ecological services. For example Australian aboriginal “dreamtime” culture explains the origins and culture of the land and its people. An understanding of these is required to respect the culture of the mining project hosts;
- Local, regional and national governance structures in which the project is operating. This may include the responsibilities of local and regional government for community development, service provision and taxation structures;
- Relationships and cultural norms of the local society;
- Social networks of the local communities;
- Opportunities for enhancing community development projects which do not undermine ecological and social systems;
• Understanding of the concerns and expectations of the local community with respect to the potential mine;

5.2 A shared meaning of Sustainability

In order to overcome the challenges faced by mining projects, project teams must learn to be innovative and creative. At all stages of the mining project it is necessary to provide an awareness of the principles for a sustainable society and what that means for a mining project and its stakeholders. By understanding the principles for a sustainable society, it creates a common language from which to evaluate how mining projects should be developed. Using principles as constraints does not dictate prescriptive requirements for achieving sustainability, thus creating the opportunity for innovation appropriate to the phase of the project being discussed.

Embedding the “success” of the project in fundamental principles for sustainability provides a holistic approach, interconnecting specific mine development disciplines (the “leaves” described in Section 1.5). Developing a vision for success for the mining project is more than determining methods to ensure the economic viability of the community post mining and minimization of negative effects. By co-creating a shared vision based on the four principles for success (i.e. sustainability), a more holistic systems based outcome can result whereby the interconnectedness of the ecological and social systems is enshrined. The visioning work should be commenced at the exploration stage and built upon for each additional project phase as it develops. The visioning and subsequent planning process should include people from various disciplines from the project team, such as engineering and design staff, geological team, economics and finance personnel and social and environmental assessment and management personnel, providing a sense of ownership and ensuring commitment:

As soon as practicable, it is also necessary to have the local community and relevant stakeholders such as government and NGOs in the visioning process, adding diversity and strengthening buy-in. project responsible for the overall strategy, delivery, and success of the project.

Once the vision has been determined, it should be shared throughout the whole project team, providing a corner stone guiding actions and decisions. Developing a vision will provide transparency to all stakeholders and
illustrate how the mining project is moving towards sustainability. It will also provide an essential direction for development actions and teams responsible for decisions within all phases of project development, exploration to closure. The community and the relevant stakeholders should be involved in the various proposals for the design of the mining project, providing an opportunity to benefit from their knowledge and to ensure transparency throughout the development process.

Additionally, community development projects are a positive move for mining projects to contribute to sustainability. However, fully considering its implications using sustainability constraints can prove to be a useful litmus test, evaluating if the community project is in the right direction to maximize societal value. Backcasting for post mining operations is particularly useful as a community engagement process. Not only will the community participate in the future of their community once the major economic activity has ceased, but it will provide a useful understanding of how they can contribute to global sustainability. Therefore in planning community development projects the emphasis should be to enhance the social and economic fabric of the local community in a manner that promotes ecological sustainability.

5.3 Putting the Vision into Action

A logical and practical way of making the vision a reality for each phase of the project is to “backcast” at each stage of the project from the overall vision of success constrained by sustainability principles. This process can highlight gaps between the current reality and the vision of success. This gap provides the creative tension for innovation and stimulates creative thinking. Several steps can be used to identify in which ways the phases of the project may contribute to violations of the sustainability principles, what actions the mining project may undertake to minimize or remove such contributions to violations and how to prioritise these actions. These steps are briefly discussed below. Appendix C provides further guidance on how to implement this process using a tool referred to as the ABCD analysis.

5.3.1 Identifying contributions to violations of Sustainability
Principles

Within the boundaries of the mining project system, the potential contributions to violations of each of the sustainability principles should be identified. This should be at each stage of the mining project from exploration to closure and post operations. The identification of potential contributions to violations should consider the mining project itself, its supply chain and its community development projects and the interactions between each of these players. This relationship is shown in Figure 5.2.

![Figure 5.2 Interconnections of project participants within sustainability constraints](image)

A list of pertinent questions and considerations to assist determine mining projects contributions to violations is provided in Appendix C. This process is one which may require participation from numerous stakeholders to identify both contributions to violations and opportunities within project boundaries. To engage as many stakeholders as possible from the local communities, the process should be made as simple as possible and be undertaken where the participants feel comfortable and are not intimidated. This process should be facilitated by someone legitimately recognised by the local community who can develop trust and ensure transparency within the process. The sustainability principles should be worded so that all stakeholders can understand their meaning and implication to enable full
contribution. The process is an iterative one that should be revisited regularly throughout the mining project.

One of the most significant advantages of backcasting from principles for sustainability is transparency. Mining projects have historically and continue to experience distrust from the local stakeholders. By embedding the projects strategies and actions within the sustainability constraints the logic and understanding is clearly visible to stakeholders. Inclusion of stakeholders in the process will assist the commitment and acceptance of the project to go ahead and an understanding of any conditions that should be included in an approval process.

5.3.2 Identify Innovative Actions

Following on from the analysis of each of the project phases, the next step is to brainstorm actions that will help each phases of the project reduce its contributions to violations of sustainability principles. Freewheeling of ideas and blue-skying in a creative and learning environment should be promoted to encourage innovation to go well beyond compliance programs while building on the progress to date. A multi-disciplined approach utilising systems thinking will look for root causes and suggest compelling actions with could offer multiple benefits across the sustainability spectrum. For example supporting a local community food program to supply the mine project has potential for multiple benefits. These include capacity building for small business and agriculture, minimising dependence on the mine for direct employment, minimising transportation requirements of imported food for the project and providing community economic development.

A similar approach could be considered for the use of mining camp buildings. Instead of importing the pre fabricated air conditioned “ATCO Trailers”, an approach to utilising local building products, local climate-appropriate design techniques and local labour could provide a stimulus to the local economy, reduce energy usage and cost implications for the mining project and leave a positive legacy for the community to utilize post operations.
5.3.3 Prioritise Initiative into Strategies

The step above allows for the brainstorming of actions, creativity and innovation. However the challenge for a mining project if it is to succeed is to create greater value (satisfying human needs in economically viable fashion) relative to ecological impacts (systemic harm to nature and people) (Herbertson 2005). The initiatives identified in the brainstorm must also be economically viable. Each mining project should consider long-term initiatives as well as quick wins which are easily implemented and which move towards the ultimate goal of sustainability, are able to be leveraged for further improvement and have an adequate return on investment.

In prioritizing actions to be implemented, the project team should ask the following:

1. **Is the proposed action assisting the project to move towards its vision of success as constrained by the Sustainability Principles?**

   In other words how does it help the project to:

   - …eliminate its contribution to systematic increases in concentrations of substances from the Earth’s crust.
   - …eliminate its contribution to systematic increases in concentrations of substances produced by society.
   - …eliminate its contribution to systematic physical degradation of nature through over-harvesting, introduction and other forms of modification.
   - …eliminate its contribution to conditions that systematically undermine people’s capacity to meet their needs.

2. **Does this action provide a stepping stone for future improvements?**

   It is likely that numerous initiatives will be required to reach the vision of success. Therefore for each initiative consider if it can be used as a flexible platform for further initiatives. If barriers exist to implement an action (e.g. an initiative is currently too expensive or the technology does not currently exist), consider what can be done now to assist its future implementation. What should be avoided are blind-alleys that tie-up capital (financial or human) in actions or initiatives that do not contribute to achieving the
vision.

**3. Will the action be likely to produce a return on investment soon enough to finance further initiatives?**

This provides an opportunity to explore how each initiative will benefit the project as defined by Willard (2005) as the 7 sustainability advantages:

1. Reduced recruitment costs
2. Reduced attrition costs
3. Increased employee productivity
4. Reduced operating expenses
5. Reduced expenses at commercial site
6. Increased revenue / market share
7. Reduced risk, easier financing
6 Conclusion

This thesis has attempted to illustrate the opportunity for mining projects to strategically contribute to sustainable development in their exploration, operations and post closure mining phases through backcasting from a principled definition of sustainability. Deriving mining activities and strategies in this way can allow for innovation, meaningful collaboration with relevant stakeholders and add value to society without systematically degrading the systems it depends upon. We believe this approach can enable many of the initiatives that mining companies are currently undertaking to be pulled together to identify interdependencies, holistically understand trade-off consequences and ensure that such actions assist mining projects to operate within sustainability constraints while adding value to society. This strategic approach will enhance and build upon the current method of meeting compliance requirements and minimising impacts. Integrating this perspective throughout mining project decision-making processes can help projects to be developed in such a way that maximises value and goes well beyond a compliance mentality.

Our studies have shown that such a position (beyond compliance) is a desirable social, environmental and economic place for companies to be. Integrating ‘backcasting from sustainability principles’ into mining project development also contributes to increasing company reputational value by a clearly defined path for achieving sustainability. Value that can be further developed through continued education, dialogue, and transparency with all team members and stakeholders. It is believed that these efforts can move the company from having to earn a ‘social licence to operate’ to being a desired community partner, employer and a robust investment opportunity. Mining projects developed in such a way can play a crucial role as an important stepping stone in moving companies towards contributing to a sustainable society. Mining Projects are crucial to help meet the societal demand for metals although the process through which they are developed stands to be greatly enhanced.

This thesis was limited in that the recommendations have not been tested in a practical application to an actual mining project. The process of a mine development project is lengthy and due to the short time frame of the thesis work a suitable project development was not available for testing. Opportunities for further research include testing the guidelines in a practical application producing relevant case studies and further research in
the viability of urban ores.

The debate whether the extraction of metals can be regarded as a legitimate part of a sustainable society continues. The demand for mined materials, specifically metals, is driven from the benefits society derives from their use. For example, current transportation methods, electronics, chemicals, power transmission, production equipment and buildings require metals. Demand for metals is currently exacerbated by the increasing industrialisation and urbanisation of rapidly growing economies of Brazil, Russia, India and China. Linking to the supply and demand debate, our studies have indicated the need for more dialogue with respect to the global finitude of metal resources contained within the lithosphere and how this perspective can inform the business actions and direction of mining companies. For example, Gordon et al (2006) estimates that the global demand for copper, based on 2006 figures for per capita consumption, will outstrip the amount of copper extractable from the ground by 2100. Mudd (2007) has reported Australia’s economic resource stocks based on 2005 production rates for various metals ranging from 17 years for gold to 97 years for bauxite for example. Even shorter time-frames are estimated for rare metals such as gallium and indium. The volume of scientific data supporting these findings is growing. Although, by understanding the Law of Conservation of Matter, we know that even if all lithospheric deposits of metals have been exhausted the metals will still exist, only to be found in less ordered and concentrated states.

The ultimate finitude of extractive resources raises a further question to be answered. That of how society can continue to develop in the face of declining metal resources available for extraction from the earth’s crust. With the depletion of stock from the lithosphere, the stock available to society to use will be that currently in the economy and that which has “leaked” from the economy and is present in wastes. Gordon et al (2005) estimate that 26% of extractable copper and 19% of lead from the earth’s crust is lost in non-recyclable wastes. However, the stone age did not end because it ran out of stone” and the mining era may or may not run out due to the exhaustion of materials to extract. The social and environmental considerations of large mining projects continue to raise challenges and expectations for the mining industry which will eventually impinge on the economic viability of virgin ore mining and hence alternative options for provision of the services of metals will need to be found.

Although the mining project itself is of a temporary nature, the lifecycle of
the metals themselves continues throughout the value chain. The advantage of metals is that they are infinitely recyclable. Once they are brought up into the technosphere from the lithosphere they can be reused over and over with the input of energy but at a much lower rate of energy required for the production of virgin ore. The metals that are currently in waste streams present an opportunity to be removed from the waste streams and made available to the economy. Therefore when discussing mining and the sustainable future, the real debate around how and from where metals will be mined instead of whether mining will exist at all.

As progress towards achieving a sustainable society advances, the challenge is to create maximum value for society without contributing to systematic degradation of life supporting resources through mining processes. Thus the actual process of mining must move away from unsustainable practices as described throughout this thesis. In a sustainable society the role of virgin mining will be one which “tops up” the metals stock in society needed due to increasing population demand. The current trend away from the linear system of using metals once only, will continue to incorporate much greater reuse of metals at the end of the initial application life. This will require that the product stewardship of metals currently in the technosphere is greatly enhanced and expanded i.e. we look after what we have already got. Applications for metals should be carefully considered so that the integrity of the metals is retained and can easily be recycled. This also means that applications which permit the dissipative use of metals such as paints, skin care and chemicals which typically disperse the metals into the environment should be avoided. This will minimise the systematic increase of metals within the biosphere and enable the continued reuse of the stock currently in the technosphere. Whether companies are sourcing metals from the lithosphere in traditional processes or by newly developed technology applied to non-traditional sources of metals, care should be given to proceeding with these activities within the constraints of the principles for sustainability.
References

Alcan 2008 Personal communication with Kariann Alstrup with the authors


BHP-Billiton 2007 Case Study

Business Speculator (2008)


http://www.pwc.com/extweb/pwcpublications.nsf/docid/ad4defb47a20ed0a852572f9007200c7 (Date accessed: January 11, 2008).

Canadian House of Commons Environment and Sustainable Development Committee (2008)


Gibson, R. 2006 Sustainability assessment and conflict resolution: Reaching agreement to proceed with the Voisey’s Bay nickel mine. *Journal of cleaner production* Vol 14 (3) 334 -348


Mudd G 2007 The Sustainability of Mining in Australia : Key Production Trends and Their Environmental Implications for the Future http://www.mpi.org.au/attachment/d016df19778a7c563cd1c99afe29c43a/f2


Teck Cominco Sustainability Report 2006  

Vale 2006 Sustainability Report  
(Date accessed 15 February 2008)


World Bank 1999 Operational Policies – Environmental Assessment  
## Appendix A: Interviewees

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Company/Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruce Harvey</td>
<td>Global Practice Leader - Community Relations</td>
<td>Rio Tinto (Australia)</td>
</tr>
<tr>
<td>Bruce McKean</td>
<td>Director, Sustainability Programs</td>
<td>Nickel Institute (Canada)</td>
</tr>
<tr>
<td>Carmen Turner</td>
<td>Officer</td>
<td>Teck Cominco (Canada)</td>
</tr>
<tr>
<td>Dave Parker</td>
<td>Director, Sustainability and Corporate Affairs</td>
<td>Teck Cominco (Canada)</td>
</tr>
<tr>
<td>Guy Gilron</td>
<td>Director, Ecological and Health Risk Assessment Research and Campaigns</td>
<td>Teck Cominco (Canada)</td>
</tr>
<tr>
<td>Helen Rosenbaum</td>
<td>Coordinator</td>
<td>The Mineral Policy Institute School of Engineering University of Queensland Australia</td>
</tr>
<tr>
<td>Jacqueline Medvečka</td>
<td>PhD Scholar</td>
<td>Teck Cominco (Canada)</td>
</tr>
<tr>
<td>Jamila Abassi</td>
<td>Manager, Sustainability Programs</td>
<td>Avanzar (Canada)</td>
</tr>
<tr>
<td>Jim Rader</td>
<td>Principle Consultant</td>
<td>ICMM (UK)</td>
</tr>
<tr>
<td>John Atherton</td>
<td>Senior Program Director International Social and Community Development</td>
<td>Teck Cominco (Canada)</td>
</tr>
<tr>
<td>Johnathan Samuel</td>
<td>Manager</td>
<td>Anglo American (UK)</td>
</tr>
<tr>
<td>Juliana Rudich Rehfeld</td>
<td>Corporate Manager, Sustainable Development</td>
<td>Anglo American (Brazil)</td>
</tr>
<tr>
<td>Kariann Aarup</td>
<td>Sustainability Consultant</td>
<td>Rio Tinto Alcan (Canada)</td>
</tr>
<tr>
<td>Marcelo Vilela Galo</td>
<td>Specialist, Environment Management, Business Manager</td>
<td>Anglo American (Brazil)</td>
</tr>
<tr>
<td>Nathan Monash</td>
<td>Sustainability Projects Director, Sustainable Development</td>
<td>Rio Tinto Alcan (Canada)</td>
</tr>
<tr>
<td>Orlando Lima Petrônio Chaves Hipólito</td>
<td>Specialist, Social Responsibility, Global Director Sustainability Manager, Sustainability Programs</td>
<td>VALE (Brazil) Anglo American (Brazil) Hatch Engineering (Australia)</td>
</tr>
<tr>
<td>Philip Bangerter</td>
<td>Manager</td>
<td>Nickel Institute (Canada)</td>
</tr>
<tr>
<td>Sofia Wong</td>
<td>Community Affairs, Manager Environment</td>
<td>Alcan (Australia)</td>
</tr>
<tr>
<td>Steve Vellacott</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: Interview Questions

Objectives: to understand…

• Challenges currently faced by [the company]
• The definition of sustainability used by [the company]
• Their criteria for determining their definition of sustainability
• How [the company]’s sustainability objectives get incorporated at the project level
• The challenges [the company] faces in implementing sustainability aspects at the project level
• How [the company] demonstrates to stakeholders that the project is contributing to sustainable development
• Corporate mindset and drivers for sustainability efforts
• How [the company] determines the extent of responsibility and sets boundaries for the project

Discussion Points

1. What are the current business challenges faced by [the company]? 
2. What methods, tools and concepts are used today to strategically solve these challenges? 
3. How does [the company] currently define sustainability? 
4. If possible, please elaborate on how the definition of sustainability has been developed? (e.g. use Brundtland Commission, ICMM principles)
5. How does sustainable development benefit [the company]? 
6. What are the main challenges of implementing sustainability into [the company’s] projects? 
7. To what extent are company defined sustainability priorities implemented at the project level? 
8. At which stages of a project lifecycle (exploration to mine closure) are [the company’s] sustainability priorities considered? 
9. To what extent is product stewardship (including contaminants)
incorporated into project planning?

10. To what extent are [the company’s] customers inquiring about the company’s sustainability performance (water, energy, and resource use)?

11. To what extent does [the company] evaluate its suppliers’ sustainability performance?

12. What stakeholders are engaged at each of the project stages?

13. What is envisioned for affected communities post-operations?
Appendix C: Guidance Document

The purpose of this guidance document is to assist individuals involved in developing mining projects understand how to look at this process using the Framework for Strategic Sustainable Development as a lens. This framework is intended to guide development towards sustainability using a whole systems perspective of the mining project impacts, identifying potential barriers and opportunities for innovation. The gap between being ‘sustainable’ and current best practices provides ample opportunities for sustainability driven innovation.

The objectives of using this guidance document are to facilitate:

- whole systems thinking – consider root causes not just problems
- consideration of Sustainability Principles in relation to mining project development
- clarity and transparency in decision-making processes
- interdisciplinary engagement and dialogue
- understanding about what aspects of projects require detailed investigation and analysis
- creativity and innovation by reconsidering traditional project development approaches
- guidance on how to prioritise short and medium term actions and how to understand the consequences of trade offs from a holistic perspective

(adapted from Herbertson 2005)
This document contains two sets of questions: Core Questions and Innovation Questions.

**Core Questions:** are intended to be applied to all specific phases of project development (exploration through mine closure) as well as deeper studies with natural systems and communities impacted by the project.

**Innovation Questions:** in this context, represent a *non-exhaustive* list of probing questions to inspire innovation and create value in new initiatives driven by sustainability challenges. Because projects are geographically and culturally diverse, trust is placed in the mining project team members to create an exhaustive list of opportunities for innovation using their experience and expertise.

These questions are part of a larger process referred to as the ABCD Analysis strategic tool. A brief explanation of this tool is outlined below:

**Step A** – Understanding the system and creating shared mental models (often the funnel metaphor is used)

**Step B** – When looking at today’s situation, critical flows and problems with reference the four sustainability principles are listed, facilitated by asking, “In what ways and to what extent are we contributing to the violations of the sustainability principles today?”

**Step C** – Envisioning of a future in which the organisation conducting the analysis is no longer part of the problem. Possible solutions are listed, disregarding whether they are economically ‘realistic’ or not in the short term. Often this is facilitated by asking, “How can the services we provide to humanity and in which cases are we specialists, be provided in a way that does not contribute to the violation of sustainability principles?”

**Step D** – Design of a strategic program for change which links the short term to the long term in a step-by-step method. Solutions are selected from the Step C that are:

1. Flexible platforms
2. Provides a good return on investment (financial, human and social capital)
3. Moves the company in the right direction towards sustainability

This process can be seen in Figure 2.2 below.
Overview of applying the FSSD and the ABCD Analysis to a mining project

It is suggested that this analysis tool be applied to all distinct phases of mine site project development, giving the sustainability initiatives, actions, tools and overall direction of the project guidance on how to move in the right direction towards achieving its sustainability goals. The core and innovation questions have been presented in a context familiar to the mining industry.
Overview of the whole systems perspective for the mining industry

Awareness of the Mining Project as part of a bigger system (Step A in an ABCD process)

The first step of this process is to gain an awareness of the system the mining project exists in from a global perspective and to create shared mental models (Step A in the ABCD process). It is assumed the reader has reviewed Sections 1.1 and 1.2 of the thesis in which this system is defined. Section 4.1 provides a deeper understanding of the system from a mining project context.

Approaching mine project development with such a mindset will link development team members together through different phases of project development, guided by a common understanding of how sustainability is defined in the four Principles for a Sustainable Society (Section 4.3). These principles set up the minimum conditions to achieve sustainability and the Core Questions can prompt the teams to fully understand their current performance. Potential barriers to achieving sustainability present opportunities for innovation and provide fertile ground for sustainability driven innovation, guided by the Framework for Strategic Sustainable Development.
Core Questions (Step B in an ABCD process)

What are the possible contributions to violations of the four sustainability principles during the different phases of mining project development?:

Considering Sustainability Principle 1.....

• Are there any strategies available to capture trace or minor elements liberated during the extraction and beneficiation processes?

• Are there ways of eliminating the projects’ contribution to the systematic increase of GHGs from lithospheric sources?

Considering Sustainability Principle 2.....

• Are there ways in which to substitute or eliminate the projects’ use of man-made substances foreign to nature which are persistent (i.e. resistant to chemical and/or metabolic degradation) and bioaccumulative?

Considering Sustainability Principle 3.....

• In what ways, if any, does the project development result in long-term degradation of natural systems through physical impacts on the land, water, soil and biodiversity?

Considering Sustainability Principle 4.....

• In what ways, if any, does the project development contribute to social, economic and political circumstances that create barriers for people to meet their needs?

Questions for Innovation (Step C in an ABCD Process)

These questions are examples of the types of questions that may arise during the Step C of an ABCD analysis of phases of a mining project. They are provided to stimulate creativity and open thought when brainstorming
potential actions in response to the Step B answers above. They are by no means exhaustive.

**Considering Sustainability Principle 1…..**

- Have energy alternatives to fossil fuels been considered? This might include solar, wind, biofuels, biomass energy sources, and/or offsets.

- Have building and infrastructure systems been designed to reduce/minimize energy use? For example, mining facility buildings (including camps and operations), and community projects could consider use of thermal mass, orientation of buildings for solar exposure, living roofs, locally sourced materials and building methods.

- Have transportation routes and methods been optimized to minimize energy use?

- Are there any local sources of information, skill and/or interest to help solve energy challenges?

- Are there opportunities to close the technical loop of material used (i.e. construction materials, consumables on site) in the mining project?

- Is there an opportunity to use non-ore waste rock for other uses rather than discard?

- Have opportunities to minimise the loss of metals from products used by society been identified throughout the value chain? What would those opportunities be?

**Considering Sustainability Principle 2…..**

- Has the mine project team identified all the persistent bioaccumulative and acutely toxic substances in use in the mine project operation? This could mean certain types of pesticides used for agricultural, disease control, de/reforestation, rodent control and insects, cleaning supplies used in operations (i.e. chlorine bleach and persistent chemicals), and waste disposal techniques (i.e. incineration).
Considering Sustainability Principle 3……

- What ecosystem services are present in the project area and does the project impact on them? How might the mine project contribute to the maintenance and enhancement of these services?

<table>
<thead>
<tr>
<th>Ecosystem Services</th>
<th>Provisioning</th>
<th>Regulating</th>
<th>Cultural</th>
<th>Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food</td>
<td>Air Quality</td>
<td>Ethical values</td>
<td>Nutrient cycling</td>
</tr>
<tr>
<td></td>
<td>Biomass Fuel</td>
<td>Climate</td>
<td></td>
<td>Primary Production</td>
</tr>
<tr>
<td></td>
<td>Biochemicals, natural medicines and pharmaceuticals</td>
<td>Water Erosion</td>
<td></td>
<td>Water cycling</td>
</tr>
<tr>
<td></td>
<td>Fibre</td>
<td>Disease</td>
<td>Recreation &amp; Ecotourism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Genetic Resources</td>
<td>Pest</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fresh Water</td>
<td>Pollination</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural Hazard</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Have mine project reliance on ecosystem services been compared to local and regional distribution of the same services and how this might affect the opportunities for others to use them?

• Are there aspects of the project’s operations that use renewable raw materials from sources that are unsustainably managed?
  
  a. Timber from processes through which degrade forest integrity
  
  b. Materials that contribute to desertification
  
  c. Food from over-harvesting (i.e. fishing, hunting, agriculture)

• Are there ways and methods to reduce the amount of rock and gravel used from mismanaged sources (for road, foundation building etc.)

• Do mine project rehabilitation techniques consider aspects of endemic biodiversity? For example is topsoil saved, have nurseries been considered to foster local plants, are there opportunities to engage local knowledge for rehabilitation?

**Considering Sustainability Principle 4…..**

• In what ways might the project be actively contributing to barriers for people to meet their needs. For example, sourcing from areas with child labour and low safety standards, overworking employees, exposing people to dangerous environments, exposure to hazardous substances or products with health risks, paying unfair wages, using misleading advertising, discrimination of workers, etc. (Benhaim et al. 2008).

• In what ways might the project create barriers by failing to provide opportunities for people to meet their needs? For example, failing to provide training, safe labour conditions, scheduling to consider traditional/cultural activities, internal communication, spaces for community participation in project decisions and true dialogue, including minority groups (women, ethnic and traditional communities).
• In what ways does the project contribute to reinforce the structural barriers in the local, regional and national level?

• Has the project considered the opportunities to influence the removal of structural barriers? For example, transparency initiatives, support in strengthening local governance structures, building community capacity for participation, distribution of mine project royalties.

• Does the project limit or enhance the ability of communities to benefit from ecosystem services? For example, livelihood and/or cultural reliance on ecosystem services.

• Are there opportunities for the mine project to contribute to capacity building in addition to mine-specific vocations and training within the local community?

• Are there opportunities for business development around energy efficiency, waste management, and recycling at a local level?

• Have opportunities for supporting communities to develop within the constraints of the 4 sustainability principles been considered?

The answers to Innovation Questions will present different situations for action and each answer needs to be evaluated using the four principles for sustainability. For example it is possible to initiate renewable energy initiatives in an unsustainable way by failing to consider the whole system perspective. It’s not an effective strategy to offset your carbon dioxide emissions by investing in monoculture tree plantations that might be below sea level in 25 years!
Prioritisation (Step D in an ABCD Analysis)

Each of the brainstormed suggestions identified in the Step C should be put through another filter to consider whether they move the project towards sustainability, are able to be leveraged for further improvement and have an adequate return on investment. In prioritizing actions to be implemented, the project team should ask the following:

1. **Is the proposed action assisting the project to move towards its vision of success as constrained by the Four Sustainability Principles?**

   In other words how does it help the project to:

   …eliminate its contribution to systematic increases in concentrations of substances from the Earth’s crust.

   …eliminate its contribution to systematic increases in concentrations of substances produced by society.

   …eliminate its contribution to systematic physical degradation of nature through over-harvesting, introduction and other forms of modification.

   …eliminate its contribution to conditions that systematically undermine people’s capacity to meet their needs.

2. **Does this action provide a stepping-stone for future improvements?**

   It is likely that numerous initiatives will be required to reach the vision of success. Therefore for each initiative consider if it can be used as a flexible platform for further initiatives. If barriers exist to implement an action (e.g. an initiative is currently too expensive or the technology does not currently exist), consider what can be done now to assist its future implementation. What should be avoided are blind-alleys that tie-up capital (financial or human) in actions or initiatives that do not contribute to achieving the vision.

3. **Will the action be likely to produce a return on investment soon enough to finance further initiatives?**

   This provides an opportunity to explore how each initiative will benefit the
project as defined by Willard (2005) as the 7 sustainability advantages:

- Reduced recruitment costs
- Reduced attrition costs
- Increased employee productivity
- Reduced operating expenses
- Reduced expenses at commercial site
- Increased revenue / market share
- Reduced risk, easier financing
Appendix D: Needs and Satisfiers

<table>
<thead>
<tr>
<th>Fundamental Human Needs</th>
<th>Being (qualities)</th>
<th>Having (things)</th>
<th>Doing (actions)</th>
<th>Interacting (settings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence</td>
<td>physical and mental health</td>
<td>food, shelter, work</td>
<td>feed, clothe, rest, work</td>
<td>Living environment, social setting</td>
</tr>
<tr>
<td>Protection</td>
<td>care, adaptability, autonomy</td>
<td>social security, health systems, work</td>
<td>co-operate, plan, take care of, help</td>
<td>Social environment, dwelling</td>
</tr>
<tr>
<td>Affection</td>
<td>respect, sense of humour, generosity, sensuality</td>
<td>Friendships, family, relationships with nature</td>
<td>share, take care of, make love, express emotions</td>
<td>Privacy, intimate spaces of togetherness</td>
</tr>
<tr>
<td>Understanding</td>
<td>critical capacity, curiosity, intuition</td>
<td>literature, teachers, policies, educational</td>
<td>analyse, study, meditate, investigate</td>
<td>Schools, families, universities, communities</td>
</tr>
<tr>
<td>Participation</td>
<td>receptiveness, dedication, sense of humour</td>
<td>responsibilities, duties, work, rights</td>
<td>cooperate, dissent, express opinions</td>
<td>associations, parties, churches, neighbourhoods</td>
</tr>
<tr>
<td>Leisure</td>
<td>imagination, tranquillity, spontaneity</td>
<td>games, parties, peace of mind</td>
<td>day-dream, remember, relax, have fun</td>
<td>landscapes, intimate spaces, places to be alone</td>
</tr>
<tr>
<td>Creation</td>
<td>imagination, boldness, inventiveness, curiosity</td>
<td>abilities, skills, work, techniques</td>
<td>invent, build, design, work, compose, interpret</td>
<td>spaces for expression, workshops, audiences</td>
</tr>
<tr>
<td>Identity</td>
<td>sense of belonging, self-esteem, consistency</td>
<td>language, religions, work, customs, values, norms</td>
<td>get to know oneself, grow, commit oneself</td>
<td>places one belongs to, everyday settings</td>
</tr>
<tr>
<td>Freedom</td>
<td>autonomy, passion, self-esteem, open-mindedness</td>
<td>equal rights</td>
<td>dissent, choose, run risks, develop awareness</td>
<td>Anywhere</td>
</tr>
</tbody>
</table>

Matrix of Needs and Satisfiers (Max-Neef et al, 1991)
### Appendix E: Societal Uses for Metals

<table>
<thead>
<tr>
<th>Common Uses of Mined Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aluminium</strong></td>
</tr>
<tr>
<td><strong>Cadmium</strong></td>
</tr>
<tr>
<td><strong>Chromium</strong></td>
</tr>
<tr>
<td><strong>Cobalt</strong></td>
</tr>
<tr>
<td><strong>Coal</strong></td>
</tr>
<tr>
<td><strong>Copper</strong></td>
</tr>
<tr>
<td><strong>Gallium</strong></td>
</tr>
<tr>
<td><strong>Gold</strong></td>
</tr>
<tr>
<td><strong>Iron</strong></td>
</tr>
<tr>
<td><strong>Lead</strong></td>
</tr>
<tr>
<td><strong>Lithium</strong></td>
</tr>
<tr>
<td><strong>Mercury</strong></td>
</tr>
<tr>
<td><strong>Molybdenum</strong></td>
</tr>
<tr>
<td><strong>Nickel</strong></td>
</tr>
<tr>
<td><strong>Platinum</strong></td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
</tr>
</tbody>
</table>

Source: MMSD 2002
# Appendix F: Tools

<table>
<thead>
<tr>
<th>Tool/Concept</th>
<th>Purpose</th>
<th>Stage of Mine Project Development</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environment and Social Impact Assessment (EIA)</strong></td>
<td>Environmental Impact Assessment (EIA) is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. (source UNEP-DTIE)</td>
<td>X  X</td>
</tr>
<tr>
<td><strong>Life Cycle Assessment (LCA)</strong></td>
<td>Method developed to assess a product's full environmental costs, from raw material to final disposal</td>
<td>X</td>
</tr>
<tr>
<td><strong>Environmental Management Systems (ex. ISO 14001, EMAS)</strong></td>
<td>An administrative tool that addresses &quot;environmental management&quot; for an organisation and helps to minimize harmful effects on the environment caused by its activities, and to achieve continual improvement of its environmental performance. (source: ISO website)</td>
<td>X  X  X  X  X</td>
</tr>
<tr>
<td><strong>Global Reporting Initiative</strong></td>
<td>A reporting tool that provides guidance and reporting standards for the mining sector on sustainability challenges within the phases of exploration, feasibility, construction, mining and metal processing (including metal fabrication and recycling), and closure.</td>
<td>X  X  X</td>
</tr>
<tr>
<td><strong>Global Compact</strong></td>
<td>The Global Compact is a framework for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labour, the environment and anti-corruption. (source: UN Global Compact Website)</td>
<td>X  X  X</td>
</tr>
<tr>
<td>Tool/Concept</td>
<td>Purpose</td>
<td>Exploration</td>
</tr>
<tr>
<td>---------------------------------------------</td>
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<tr>
<td><strong>ICMM Community Development Toolkit</strong></td>
<td>Toolkit developed to support government, industry, and community efforts to realize more sustainable community development around mining and mineral processing operations. It contains 17 Tools which cover the assessment, planning, management, and evaluation phases of community development as well as stakeholder relationships. (source: ICMM Website)</td>
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<tr>
<td><strong>Resource Endowment Toolkit</strong></td>
<td>A practical toolkit to assess local, regional and national socio-economic impacts of mining. The toolkit also deals with how mining operations impact on governance structures, institutions and policy changes at different levels of government. (source: ICMM Website)</td>
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<tr>
<td><strong>Risk Assessment Tools</strong></td>
<td>Is a systematic method for examining complex facilities or processes to find actual or potentially hazardous procedures and operations so that they may be eliminated or mitigated</td>
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