



Australian Government

Department of Industry  
Tourism and Resources

# STEWARDSHIP

LEADING PRACTICE SUSTAINABLE  
DEVELOPMENT PROGRAM FOR  
THE MINING INDUSTRY



SOCIAL  
ECONOMIC  
ENVIRONMENTAL



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DEVELOPMENT PROGRAM FOR  
THE MINING INDUSTRY

# STEWARDSHIP



OCTOBER 2006

## **Disclaimer**

Leading Practice Sustainable Development Program for the Mining Industry

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## FOREWORD

The Australian mining industry is well aligned to the global pursuit of sustainable development. A commitment to leading practice sustainable development is critical for a mining company to gain and maintain its 'social licence to operate' in the community.

The handbooks in the Leading Practice Sustainable Development in Mining series integrate environmental, economic and social aspects through all phases of mineral production from exploration through construction, operation and mine site closure. The concept of leading practice is simply the best way of doing things at a given site. As new challenges emerge and new solutions are developed, or better solutions are devised for existing issues, it is important that leading practice be flexible and innovative in developing solutions that match site-specific requirements. Although there are underpinning principles, leading practice is as much about approach and attitude as it is about a fixed set of practices or a particular technology. Leading practice also involves the concept of 'adaptive management', a process of constant review and 'learning by doing' through applying the best of scientific principles.

The International Council on Mining and Metals (ICMM) definition of sustainable development for the mining and metals sector means that investments should be technically appropriate, environmentally sound, financially profitable and socially responsible. *Enduring Value – the Australian Minerals Industry Framework for Sustainable Development* provides guidance for operational level implementation of the ICMM Principles and elements by the Australian mining industry.

A range of organisations have been represented on the steering committee and working groups, indicative of the diversity of interest in mining industry leading practice. These organisations include the Department of Industry, Tourism and Resources; the Department of the Environment and Heritage; the Department of Industry and Resources (Western Australia); the Department of Natural Resources and Mines (Queensland); the Department of Primary Industries (Victoria); the Minerals Council of Australia; the Australian Centre for Minerals Extension and Research, the university sector and representatives from mining companies, the technical research sector, mining, environmental and social consultants; and non-government organisations. These groups worked together to collect and present information on a variety of topics that illustrate and explain leading practice sustainable development in Australia's mining industry.

The resulting publications are designed to assist all sectors of the mining industry to reduce the negative impacts of minerals production on the community and the environment by following the principles of leading practice sustainable development. They are an investment in the sustainability of a very important sector of our economy and the protection of our natural heritage.

**The Hon Ian Macfarlane MP**  
Minister for Industry, Tourism and Resources





# 1.0 INTRODUCTION

This handbook addresses the theme of stewardship, which is one theme in the Leading Practice Sustainable Development Program. The program aims to identify key issues affecting sustainable development in the mining industry and provide information and case studies that illustrate a more sustainable basis for the industry.

This handbook has been written to encourage mine and marketing managers, as well as customers, to apply the principles of stewardship and play a critical role in continuously improving the mining industry's sustainable development performance. At the mine, the stewardship aspects of exploration, feasibility, design, construction, operation and closure are important. Beyond the mine gate, the stewardship of minerals products in the marketplace is also crucial. While the principles guiding leading practice are often generic, they can be used to support site-specific sustainability planning.

In addition, people with an interest in leading practice in the mining industry particularly environmental officers, mining consultants, governments and regulators, non-government organisations, mine communities and students will find this handbook relevant. It has been written to encourage these people to play a critical role in continuously improving the mining industry's sustainable development performance.

## 1.1 Sustainable development

The most widely accepted definition of sustainable development is provided in the World Commission of Environment and Development in its landmark report *Our Common Future* (the Brundtland Report)–'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. There have been attempts to restate and expand this definition, often with relevance to particular sectors or populations, and some of these will be explored later in the handbook.

In the minerals sector, sustainable development means that investments in minerals projects should be financially profitable, technically appropriate, environmentally sound and socially responsible. Businesses involved in extracting non-renewable resources have come under mounting pressure to embed the concept of sustainability into strategic decision-making processes and operations. In addition to these considerations, responsible corporations have been able to move towards sustainability by developing a range of appropriate stewardship initiatives.

Economic development, environmental impact and social responsibilities must be well managed, and productive relationships must exist between governments, industry and stakeholders. Achieving such a situation is simply a 'good way to do business'.

An important statement of sustainable development principles is contained in *Enduring Value—the Australian Minerals Industry Framework for Sustainable Development*. This framework supports the implementation of sustainable development principles in the Australian mining industry. Enduring Value has a strong focus on stewardship and follows the management of materials throughout their life cycle. It seeks to:

- maximise returns and efficiencies
- better manage the social and environmental impacts
- better manage potential benefits of their production and use.

Materials stewardship is an emerging concept within the industry which supports the sustainable and equitable production and use of minerals and metals in products.

Enduring Value, which replaced the Minerals Industry Code for Environmental Management, is now the principal framework for supporting the up-take of policies to ensure that current activities in the minerals sector do not compromise the ability of future generations to meet their own needs. The Enduring Value framework aligns with global industry initiatives and, in particular, provides critical guidance on the International Council on Mining and Metals (ICMM) Sustainable Development Principles and their application at the operational level. This includes product stewardship, environmental stewardship and corporate social responsibility principles. The framework provides a vehicle for industry differentiation and leadership and, as described later, will provide long-term benefits to industry and the community through effective management of Australia's natural resources.

## 1.2 What is stewardship?

The mining industry provides mineral and metal materials that are essential elements in a wide array of goods and services that create value by meeting human needs. Mining and processing activities are an integral part of complex material cycles in society which, in turn, interact with natural material cycles and ecosystems. Companies are an essential part of value chains and life cycles that we do not control. The sustainability of the industry is about helping to manage these cycles in ways that maximise the value to society while minimising negative impacts, be they economic, social or ecological. Taking some shared responsibility for performance beyond one's direct control is at the heart of the notion of stewardship, which is fundamentally about getting better at delivering value at the whole system level. Effective stewardship becomes the driver for innovation in the ways we operate and think about our businesses.

Stewardship involves the care and management of a commodity through its life cycle. The idea of a life cycle is explored in greater detail in the next section, but it is immediately apparent that this can cover the exploration, mining, processing, refining, fabricating, use, recovery, recycling and disposal of a mineral product. Stewardship needs to be an integrated program of actions aimed at ensuring that all materials, processes, goods and services are managed throughout the life cycle in a socially and environmentally responsible manner.

Stewardship is an evolving concept within the mining industry aimed at building partnerships throughout the life cycle of materials to ensure the sustainability of their production, use and disposal. While participants in each sector have a responsibility for stewardship in their specific industry, it is a fundamental principle of stewardship that those participants also have a concern in the other industries of the life cycle.

One proposed model is shown in Figure 1. This shows three different types of stewardship (resource, process and product) falling within an umbrella of materials stewardship. The links to other global sustainable development initiatives are brought out in subsequent sections of this handbook.

**Figure 1: Materials stewardship model**



**Resource stewardship** involves a program of actions to ensure that resource inputs to a process—including the minerals, water, chemicals and energy—are being used for their most efficient and appropriate use.

**Process stewardship** involves a program of actions focused on ensuring that processes—such as beneficiation, flocculation, crushing, gravimetric separation and others that are used to produce ores, concentrates and other mineral products—are undertaken in a socially and environmentally responsible manner.

**Product stewardship**, perhaps the best known form of stewardship, is a product-centred approach to protecting human health and the environment. It aims to minimise the net environmental impact from product use—including its manufacturing, distribution, servicing, and end-of-life management—through product and product system design, as well as regulatory controls and provision of appropriate to each segment of the life cycle. This is a product-focused approach that attempts to engage people who may be involved at any point in the life cycle.

Under a broader scheme of product responsibility, or stewardship, other stakeholders (partners) who would share responsibility include consumers (responsible use and disposal of the material) and recyclers or waste managers who deal with products at end of life.

**Materials stewardship** overarches the stewardship approach since it applies to resources, processes and products and so covers the full life cycle. The overall intent of materials stewardship is best captured by the notion of doing more with less, or eco-efficiency, as defined by the World Business Council for Sustainable Development (WBCSD).

The WBCSD coined the term eco-efficiency for business to get involved in sustainable development. Eco-efficiency is 'reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's carrying capacity' (WBCSD, 2000).

Complementary to eco-efficiency is cleaner production, meaning the continuous application of an integrated, preventive, environmental strategy to processes, products, and services in ways that increase efficiency and reduce risks to humans and the environment (van Berkel, 2002). By reducing pollution and waste at the source, and striving for continuous improvement, cleaner production can bring financial as well as environmental benefits.

Industrial ecology is the study of the flows of materials and energy in industrial and consumer activities, the effects of these flows on the environment, and the influences of economic, political, regulatory and social factors on the flow, use and transformation of resources. In particular, there is a focus on mimicking the overall processes within natural systems, where the waste products from one process provide the input materials for others.

Recent approaches to product design have shown that there are significant financial and environmental savings to be made by redesigning products to minimise their environmental impact. Known internationally as design for the environment or eco-design, this approach examines a product's entire lifecycle and proposes changes in product design to minimise its environmental impact from manufacturing and distribution and during and after use.

### **Other stewardship statements**

More philosophical statements of stewardship concepts are often used and may be encountered in literature from a range of sources. One statement that has been advanced in recent Australian publications (*Strategic Framework for Tailings Management and Strategic Framework for Water Management in the Minerals Industry*) is that, 'stewardship is an approach to natural resource management that is based on the idea of the developer being a temporary custodian of community assets'.



## 2.0 WHY PRACTISE STEWARDSHIP?

### 2.1 Maintaining a licence to operate

In recent years, businesses have come under increasing pressure from governments, consumers, shareholders, competitors, investors and communities to balance their pursuit of economic gain with environmental and social concerns and, by doing so, demonstrate their contribution to sustainable development. The mining industry faces a need to gain and maintain its legitimacy and social acceptance, and cannot rely merely on the fact it claims to be in compliance with national and local environmental laws to achieve this. It is particularly vulnerable to criticisms from a combination of local and international non-government organisations (NGOs) and can no longer rely only on claims of compliance with local environmental laws (van Berkel, 2006; Bossilkov, 2005). Achieving broad acceptance by the community, as well as by regulators, is often broadly spoken of as 'having a licence to operate'. Today, licence to operate not only covers the licence to conduct business at a site but also the licence to sell products in the marketplace.

This point is a significant one, since the mining industry is the start of the life cycle for many products that are essential for modern society. Its Enduring Value framework provides advice for building social capital with the community, government, and finance and insurance sectors. It provides guidance to help the industry operate in a manner that is attuned to community expectations.

The social licence to operate extends to the notions of the 'licence to market' and the 'licence to develop', which are powerful business drivers. Growth magnifies the capacity to deliver value, but without innovation that addresses environmental and social concerns, growth magnifies the impacts of the business. Growth brings forward opportunities and challenges. Stewardship for social and environmental performance becomes a central issue for companies who seek sustainable growth.

### 2.2 The business case for stewardship

The key benefits of a well-implemented stewardship plan are:

- reduced consumption of energy, water and other auxiliaries in product delivery and use
- reduced levels of emissions that pose a hazard to humans or the environment
- reduced product waste, including maximising reuse and recycling opportunities.

An essential element of stewardship is the provision of appropriate management information to people who may be involved at any point in the life cycle.

Examples of product stewardship are often found in manufacturing industries and in markets with high product differentiation and branding, such as jewellery and high technology.

An example of this principle in practice is the leasing and take-back arrangements for office equipment, such as the take-back and remanufacture of toner cartridges or even entire photocopiers (see the Xerox case study in Section 4.1).

In considering eco-efficiency, the World Business Council for Sustainable Development identified seven components which can deliver business value: reduction of material intensity of goods and services; reduction of energy intensity of goods and services; reduction of toxic dispersion; enhancement of material recyclability; maximisation of sustainable use of renewable resources; extension of product durability; and increase in the service intensity of goods and services (WBCSD, 2000).

Leadership companies will not see sustainability as a compliance issue, but one that will shape their future processes, products, services and relationships. Adopting sustainability as a business strategy leads to a focus on innovation and value creation. It is therefore a powerful means of motivating managers and employees towards sound management of complex material cycles that underpin their business and, in a broader sense, the whole of society. Acting sustainably means taking a long-term, whole-of-business view. It can help companies to remodel the life cycle for their operations. Finding the right balance between business development and actual and perceived impacts involves understanding where there might be constraints and where there will be rewards.

### **Case study: Uranium stewardship—taking up the challenge**

The mining industry's social licence to operate, to market and to develop is under increasing pressure, as the community becomes more educated, informed and aware. Additional pressure is coming from the downstream users of the mining industry's products. These processors, manufacturers, users and recyclers are being pressured by their stakeholders to identify the primary sources of commodities.

The global uranium market is forecast to undergo a major expansion due to an anticipated increase in global demand for uranium, rising uranium prices and growing recognition of the potential greenhouse benefits of nuclear power.

Australia holds approximately 36 per cent of the world's low-cost uranium resources (less than US\$40 per kilogram), and is well placed to benefit from any expansion in the global uranium market.

In August 2005 the Hon Ian Macfarlane MP, Minister for Industry, Tourism and Resources, initiated the development of a Uranium Industry Framework (UIF). The objective of the UIF is to identify opportunities for, and impediments to, the sustainable development of the Australian uranium mining industry over the short, medium and longer term. The UIF is being developed in partnership with relevant state or territory governments, industry and other stakeholders.

In recognition of the role of stewardship in the drive to achieve sustainability, the UIF established the Uranium Stewardship Working Group. One of the recommendations of the Working Group was:



'That the Australian uranium industry establishes a uranium stewardship platform as the basis for engagement with the global uranium stewardship programs currently being developed by the World Nuclear Association.'

The World Nuclear Association (WNA) is the global organisation that seeks to promote the peaceful worldwide use of nuclear power as a sustainable energy resource for the coming centuries. Specifically, the WNA is concerned with nuclear power generation and all aspects of the nuclear fuel cycle, including mining, conversion, enrichment, fuel fabrication, plant manufacture, transport, and the safe disposition of spent fuel. Current WNA members are responsible for some 90% of the world's nuclear-generated electricity outside the USA and 90% of world uranium, conversion and enrichment production.

The inaugural meeting of the WNA Uranium Stewardship Working Group was held in London in June 2006 and all sectors of the nuclear life cycle were represented by the foundation members of the working group. The WNA Uranium Stewardship Working Group's definition of uranium stewardship is:

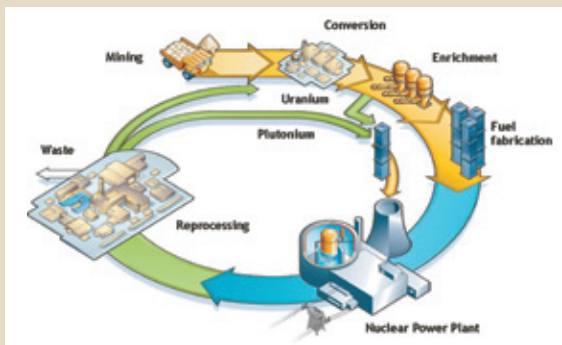
'a programme of action to demonstrate that uranium is produced, used and disposed of in a safe and acceptable manner. The programme takes a life cycle approach and encourages use of leading practices for health, safety, environment, and social aspects along the value chain and emphasises waste minimisation and encourages recycling'.

The establishment of best, leading practice—together with a shared responsibility approach is aimed at achieving two fundamentally important results:

- improving the competitiveness of the industry by developing an integrated approach and a 'learning-by-sharing' process
- ensuring that 'leading' practice becomes 'standard' practice throughout the life cycle.

Long-term management of nuclear waste is stewardship issue that requires industry, government and the community to reach agreement on appropriate treatment techniques and sites for repositories. Such agreement has so far been reached in some but not all relevant countries.

### **Nuclear fuel cycle**



Source: World Nuclear Association

## 2.3 Who should be involved in stewardship?

People who should be involved in stewardship include anyone who has anything to do with the material, from the time of prospecting for the resource through mining, processing, manufacture, use and recovery or recycling.

Taking this further, however, we need to define the participants in stewardship, both the stewards and those on whose behalf stewardship is exercised. Producers who are intensive users of resources and consumers of energy are usually involved in the pre-use part of the product life cycle and they have often played the stewardship role.

A different situation exists with the extended producer responsibility (EPR) systems that have been imposed in some jurisdictions, notably in Europe, Japan and Korea. Under an EPR regime, responsibility for managing the environmental or social impacts of a product or service is assigned solely to one player in the life cycle, normally the one who places the product on the market. The defining characteristic of EPR schemes is their mandatory nature as compared with voluntary product stewardship schemes. Most include a legislated requirement for producers either to take back products at the end of their life or to take responsibility in some other way for the product at the end of its life, for example, through paying for recycling schemes. The claimed advantage of nominating a single entity to take responsibility is that when all players are involved there is a risk of having none of them involved, each expecting someone else to act. This is known, more generally, as 'the tragedy of the commons'.

A preferred approach to stewardship is a shared approach that attempts to build engagement throughout the life cycle, including with suppliers and customers. Under a broader scheme of product responsibility or stewardship, particular emphasis is placed on cooperation and partnership among these other stakeholders (partners) who share responsibility. This means not just consumers (from whom one can expect responsible use and disposal of the material) but also recyclers or waste managers who deal with products at end of life.

## 2.4 Co-regulation

Actions by industry to manage waste and other environmental impacts from its products can vary along a continuum from voluntary to fully regulated approaches. While voluntary product stewardship schemes may be able to gain majority sector participation for their initiatives, there will always be some companies that will not participate voluntarily and—since some cost is involved in adhering to the scheme—these companies might thereby gain an unfair market advantage. Such considerations have given impetus to an approach that is well supported by industry in Australia, namely, voluntary sector initiatives underpinned by a regulatory safety net to capture free-riders. This approach is known as co-regulation.

An example of a co-regulatory scheme is the Product Stewardship for Oil program for recovering lubricants and oils, being run under the *Commonwealth Product Stewardship (Oil) Act 2000* for the recovery and recycling of used lubricants and oils.

The television and tyre sectors have approached Australian governments to develop a national 'regulatory safety net' to ensure a level playing field by requiring similar outcomes from non-participants in voluntary sector schemes. The same motive led to the development of the National Environment Protection Measure (NEPM) for Used Packaging Materials that underpins the voluntary National Packaging Covenant.

Concerns over the use of sodium cyanide in the international gold industry have led to the development of a voluntary industry code for the management of this highly toxic substance. The *International Cyanide Management Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold* was developed by a multi-stakeholder group under the auspices of the United Nations Environment Programme and the ICMM. The Code, located at [www.cyanidecode.org/](http://www.cyanidecode.org/), is managed by the International Cyanide Management Institute. The institute promotes the Code to all stakeholders and encourages its adoption by industry to protect people and the environment. In most countries cyanide management is the subject of environmental regulations which, together with the industry initiative, provide co-regulation.

Other sectors have advocated co-regulatory schemes, notably through the work of the World Business Council for Sustainable Development (WBCSD). An example in the minerals sector is the Mining, Minerals and Sustainable Development Project. This project preceded the formulation of the mining industry's sustainability charter. The WBCSD was established to coordinate the input of global business to the Earth Summit in Rio in 1992. It fosters sustainable development and has stewardship elements in its key program areas of eco-efficiency, corporate social responsibility, and accountability and transparency.

## 2.5 Involvement of non-government organisations

Industry bodies or individual businesses may set up consultative groups to advise on particular projects, to give on-going advice, to critique an annual environment report or, in a growing number of cases, to provide third-party certification of the company's operations. Consultation with non-government organisations (NGOs) ensures views from outside the professional community are canvassed. In general, NGOs are more cautious in their assessment of risks and less optimistic about benefits. Through their participation in detailed consultations, companies get forewarning of likely community reactions to their present and future operations.

In exchange for their involvement and contributions, NGOs become better informed and are encouraged to continue their involvement (which is generally voluntary and unpaid) on behalf of their communities, when companies listen to their advice.

Industry organisations and individual mining companies may also establish consultative groups or involve NGOs in other ways. For example, the Minerals Council of Australia also has NGO representation on its External Advisory Panel.

Australian Government departments and regulatory agencies have ongoing consultation with NGOs. Community-based NGOs often have a special interest in the environment, while industry NGOs are usually sector-based.

## 2.6 International regulatory drivers

Australia has ratified all the international conventions requiring the reduction or elimination of certain chemicals and their wastes to limit their impact on human health and the environment. These conventions, administered by various United Nations agencies, are regulatory drivers for the management of chemical substances in Australia.

Perhaps the most important of these, for the mining industry, is the Basel Convention, which aims to implement the legal, institutional and technical conditions in a party, in order to achieve environmentally sound management of hazardous wastes, from their generation to elimination. This implies management as close as possible to source and militates against transboundary shipment. There is a fine line between products and wastes, so the industry needs to be aware that wastes containing metals (antimony, arsenic, beryllium, cadmium, chromium (VI), copper, mercury, selenium, tellurium, thallium and zinc) or their compounds are subject to the convention.

Next in relevance is the Rotterdam Convention, the objective of which is to monitor and control the trade of hazardous substances. It gives importing countries the power to decide which chemicals they want to receive and to exclude those they cannot manage safely. This means that the export of a chemical can only take place with the prior informed consent of the importing party. If trade does take place, requirements for labelling and provision of information on potential health and environmental effects promote the safe use of these chemicals. Most of the substances listed under the convention are organic chemicals, but mercury and compounds, asbestos and tributyl tin compounds are also covered.

The Strategic Approach to International Chemicals Management (SAICM) is a policy framework for international action on chemical hazards that was agreed at a multinational meeting held under United Nations auspices in February 2006. The definition of 'chemical' is very wide and could include some mineral products.

Two other conventions that have less direct relevance to the mining industry are the Montreal Protocol (to the Vienna Convention) for protection of the ozone layer and the Stockholm Convention on Persistent Organic Pollutants. Both conventions deal with organic chemicals, and their implementation in Australia is ongoing. Most people will be familiar with the phase out of CFCs and related substances under the Montreal Protocol. Less well known is the relevance of the Stockholm Convention. Unintentional emissions of such substances as polychlorodibenzo-dioxins and furans, and hexachlorobenzene during mineral processing, are covered by the convention (and Australia's National Implementation Plan) which requires their minimisation or elimination. Internet links to these conventions are provided at the end of this handbook.



## 3.0 DEFINING THE LIFE CYCLE OF MINERALS

An understanding of an industry's life cycle is an essential requirement for stewardship. A life cycle assessment can be extremely valuable to assist decision making. To make such an assessment, a company needs to examine each step in the life cycle of a product, including those that are easily overlooked, such as the fate of the product after its useful life.

These steps will typically include the extracting and processing of materials; manufacturing, transportation and distribution; use, reuse, maintenance; recycling and final disposal.

Final disposal may be subdivided to include landfill, secure containment, incineration or dispersion into the environment. When identifying each step in this fashion, the focus is on its attendant use of resources (including water, air and energy), its actual or potential environmental impacts and such factors as efficiency and occupational health and safety.

A life cycle assessment (LCA), sometimes called life cycle analysis, is defined by the Society of Environmental Toxicology and Chemistry as:

'...an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impact of those energy and materials uses and releases on the environment, and to evaluate and implement opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity ...' (Fava et al.,1991, p. 1).

LCA is therefore the process of quantifying a product's environmental impacts from 'the cradle to the grave' and can provide quantitative results by which to measure progress, such as energy reductions across a production process.

The life cycle of a product may be expressed in a diagram, like that devised for the Green Lead program (see case study in Section 3.1).

The key components of a life cycle include:

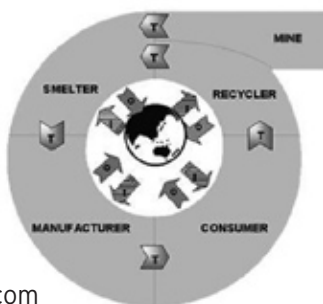
- The major sectors in the life cycle of products – each sector is responsible for the stewardship of its own sector and is concerned about the stewardship of the product as it moves through the lifecycle.
- Each sector is connected by a transport link – the chain of custody between the sectors needs to be incorporated into the product stewardship agenda (see RightShip case study).
- Each sector has its own (possibly unique) potential interaction with and from people and planet and, at the same time, is part of a common link with the other sectors in the product life cycle.
- The outputs (arrows pointing from the life cycle to the earth) at and between each sector of the life cycle represent the impacts that the product might have on

the biosphere. These impacts might be a result of the product itself (such as lead) or the processing of the product (such as greenhouse gases or wastes).

- The inputs (arrows from earth to the life cycle) represent the 'biosphere contribution' to the product movement throughout the life cycle—these 'contributions' might be resources, energy or water.

Ideally, once metals get beyond the mine gate, we should see them as involved in closed loops which involve manufacturing, use and recycling. In such cases, stewardship is to ensure that materials are contained. However, some uses of metals are dispersive, for example those of titanium oxide (TiO<sub>2</sub>), and by their nature may not permit recovery and recycling. Stewardship in these cases implies the phasing out of these materials from dispersive applications, where a hazard has been established.

**Figure 2: Key components of a product life cycle**



Source: [www.greenlead.com](http://www.greenlead.com)

The outcome of an LCA may be counter-intuitive, since the analysis takes in factors that are not considered in casual judgments. These are likely to be more influenced by just one, albeit highly visible, step or environmental impact in the life cycle.

For example, the higher energy consumption and greenhouse gas emissions for producing aluminium and other light metals, compared with iron and steel, may become more than compensated by better fuel efficiency when lighter metals are used in automobiles. LCA studies have shown a reduction of 20 kilograms of carbon dioxide-equivalent (CO<sub>2</sub>-eq) greenhouse gas emissions over the life cycle of an automobile per kilogram of aluminium used. Equally, clever design for light weighting using steel has been demonstrated.

In the mining industry, stewardship includes the management of waste rock and tailings, with careful emplacement to ensure containment against deleterious discharges and for possible reuse as future resources. Such cradle-to-grave life cycle stewardship is an extension of current mineral sector stewardship in water, land and ecosystem management, and community collaboration. The mining industry can expect market pressure for more environmentally-friendly products. Part of the pressure is likely to come from companies doing life cycle assessments of the minerals and metals they buy.

LCA is an environmental management tool in the ISO14040 series that has found particular favour across a wide range of industries. Companies that adopt LCA accept their position as a 'materials steward' for the environment. When deciding how to minimise environmental impacts, these companies are required to consider the entire life cycle of the materials that they handle.

This means that, rather than merely identifying the potential hazards from one process or site, the company will consider potential hazards arising from all activities in the supply chain, both upstream and downstream. The results of the analysis can then be made available to help upstream and downstream users assess if it might be environmentally responsible to engage commercially with any other user in the supply chain. More significantly, contributors to the LCA can modify their own processes to facilitate waste minimisation, reuse or recycling at a later stage.

Several mining companies have begun integrating LCA into their environmental management systems although, in general, industry attitudes to LCA are mixed. Despite the existence of international standards ISO 14040–14043 for LCA procedures, there remains a need to further standardise LCA methodology, particularly in relation to scoping of the study (which parts of the life cycle are being studied and which environmental impacts are considered) and the environmental impact categories considered.

An example of an imbalanced approach would be for some players to be forced to accept uneconomic obligations because of the poor performance of others who might be involved in the life cycle. It is in the interests of the mining industry to play a part in shaping the form of materials stewardship given that the eventual form will determine liabilities for environmental harm for companies and professionals, and determine the steps that risk assessment professionals will need to take.

If stewardship is seen as a voluntary corporate sustainability initiative based on shared responsibility, LCA across the supply chain can provide a clearer picture of what is actually going on. It will help to identify the factors that contribute to the potential harm so that those processes can be properly modified for a better outcome. More detail on LCA can be found in Appendix A to this handbook.

The Enduring Value framework includes the Principles and Elements adopted by the ICMM and the accompanying implementation guidance notes, and these can be used to develop more sustainable practices as part of a life cycle approach.

**Table 1: Enduring value: Principles and elements for a life cycle approach**

ICMM Principle/ Guidance Element	Description
<b>Principle 8</b>	Facilitate and encourage responsible product design, use, reuse, recycling and disposal of our products.
<b>Element 8.1</b>	Advance understanding of the properties of metals and minerals and their life cycle effects on human health and the environment.
<b>Guidance</b>	Where appropriate, support research that improves understanding of the life cycle effects of minerals and metal products on human and environmental health. Monitor and review the impacts of exploration and operations on occupational, community and environmental health, taking into account advances in the understanding of life cycle issues (see elements 1.4, 2.4, 4.1, 6.1, 7.2, 7.3, 8.3).



## 4.0 STEWARDSHIP CONCEPTS AND PRACTICES

The notions of stewardship and its application to mining and minerals are still relatively new and emerging. Different interpretations may be found in the literature, but such diversity can be useful for implementing the concept in different industry settings. In general, stewardship is an integrated program of action aimed at ensuring that all materials, processes, goods or services are produced, consumed and disposed of along the life cycle, in a socially and environmentally responsible manner.

Although the definitions applied to various aspects of stewardship are still subject to debate the definitions are somewhat loose and there is some overlap it is convenient to use a framework that allows the most applicable concepts and tools to be easily recognised by different participants of the life cycle. These approaches build upon one another and are not intended to be mutually exclusive. They provide a starting point for operators, at different stages of the mining and mineral life cycle, who wish to incorporate stewardship into their operations. Resource stewardship is most logically initiated from the mine level, process stewardship from the minerals processing level and product stewardship by the users of the primary metals and minerals.

**Figure 3: Materials stewardship model**



### 4.1 Materials stewardship

Stewardship focuses on management of natural resource flows which the mining industry has termed 'materials'. These materials include the mined deposit, ore, overburden and rock, as well as the materials and chemicals used for extraction and processing, such as explosives, reagents and fuels. Moreover, materials include energy and water, both vital inputs for mining and minerals operations.

Applying the general definition of materials stewardship to the specific case of minerals unites the entire life cycle of a mineral. Materials stewardship is about understanding the risks that a mineral, either directly or in any of its processed forms, can pose to people or the environment, at any stage or in any form during the life cycle of that mineral. Materials stewardship requires a good understanding of the eco-toxicity and human toxicity of the mineral (and metal), and the bioavailability of the mineral, depending on what the mineral speciation is. Materials stewardship can also identify inappropriate uses of a mineral which might cause serious harm to people or the environment if not managed properly.



While considerable attention is rightly given to the environmental aspects of stewardship, the health-related aspects of mining and minerals operations are also vital components of stewardship initiatives.

In this context, the Minerals Industry Risk Management Gateway (MIRMGate) provides a leading practice example of communication across the industry in order to minimise workplace hazards. It is important to note that the environmental management tools provided by the ISO 14000 series do not include a number of quantitative targets that would assist managers in gauging the success of a stewardship program. Of particular concern is the limited use of what is known as environmental condition indicators that would measure actual impacts on human health such as blood lead levels or environmental conditions, such as stream sediment loads or biota counts.

### **Case study: Minerals Industry Risk Management Gateway**

The Minerals Industry Risk Management Gateway supports hazard identification and risk management in mining and minerals operations. The website is managed by the Minerals Industry Safety & Health Centre (MISHC), part of the Sustainable Minerals Institute, at the University of Queensland in Brisbane.

MIRMGate is a user-friendly, valuable resource for decision makers in the mining and minerals industry. It offers carefully selected good practice information for the understanding, analysis and control of industry risks from exploration through to minerals processing.

It was launched in March 2004 with the aim of helping users to identify hazards throughout the entire life cycle of mining and minerals operations, and encourage collaboration and knowledge sharing between the minerals sector, governments, institutions, organisations and companies.

MIRMGate was initially funded by Australian state and territory governments with good practice guidance sourced from government agencies. Funding for ongoing development of MIRMGate was subsequently provided by the Australian minerals industry, initially by individual companies, and currently through the Minerals Council of Australia. Recognising MIRMGate's potential to play a lead role in fostering better industry performance, community relations and regulatory approaches around the world, ICMM provided additional support during 2005 and 2006. ICMM funds have been used to acquire improved hardware and develop global resources, improve international awareness and use of the site, and provide editorial guidance on new resources entered into the site.

The targets set for the number of global resources to be added in 2005 were exceeded by more than three times and the 2006 targets were surpassed by mid-year. In all, more than 850 new global resource records and more than 250 new global lessons-learned records have been added as a result of ICMM's funding. Contributors have included ICMM members; safety and health regulators in Canada, the European Union, South Africa, and the USA; the International Labour Organisation; and the International Association of Oil

and Gas Producers (OGP). There were almost 27 000 visits to the site in 2005 and, with 7000 visits in January 2006, it is expected that this figure will be exceeded in 2006.

MIRMGate resources are ranked in three areas to suit the risk assessment tasks undertaken at sites: relevance to hazard identification, risk analysis and adequate control identification. MIRMGate also provides a growing source of information on lessons learned from industry incidents, as well as industry-recognised innovations that potentially help reduce risk. Updates on MIRMGate are emailed to ICMM members each quarter. Further information is available from the MIRMGate web site [www.mirmgate.com](http://www.mirmgate.com).

Risk management will often include reduced exposure to hazards in the workplace and more generally through release to the environment, providing a synergy with the aims of improved stewardship at every stage of the mineral cycle.

Materials stewardship requires a good tracking system to enable the stewards of a particular mineral to know how it is being used and what products it is used in. In most cases, there will be an overlap with initiatives taken under the heading of product stewardship, as shown in the Green Lead™ case study.

### **Case study: Green Lead™**

The aim of the Green Lead™ project is to minimise the risk of harm to people and the environment from exposure to lead at any place in the life cycle of lead acid batteries (LABs) from the mining of primary lead to the recycling and production of secondary lead from lead acid batteries. It is based on a product stewardship model involving shared responsibility for lead around its life cycle. While it is recognised that there are other (and sometimes more dispersive) uses for lead, this was the first attempt by the mining industry to establish a stewardship program and it was decided to focus on the principal (over 80 per cent) end use of lead—LABs.

The Green Lead™ initiative was conceived at BHP Billiton Cannington, the world's largest silver and lead producing mine, in north-west Queensland. It has since developed into the Green Lead™ Consortium that includes contributions from significant Australian lead miners or processors BHP Billiton, Zinifex, Xstrata and Australian Refined Alloys. The consortium also includes several international companies, industry and commodity associations, as well as inter-government and non-government organisations, including the United Nations Environment Programme (UNEP), the Basel Convention Secretariat, the Common Fund for Commodities, the International Lead Zinc Study Group, the International Lead Zinc Research Organisation, the International

Lead Management Centre, International Council for Mining and Metals, Lead Development Association International, Britannia Refined Metals, Anglo

American, Falconbridge, Philippines Batteries International, the Ramcar Group of Companies, Oriental & Motolite and Ford Motor Company.

The toxic environmental and human health impacts of lead are well known. As a result, in several countries, lead has been phased out of some products, residential paints and on-road automotive fuels. Denmark for example now only allows lead in batteries and X-ray shielding.

In Australia and some other countries, strict regulations have been implemented, including a ban under the Basel Convention, on trans-boundary shipments of hazardous wastes including lead from European Union (EU) or Organisation for Economic Co-operation and Development (OECD) to non-EU or non-OECD countries. In Europe, extended producer responsibility laws will have profound effects on lead producers and battery manufacturers.

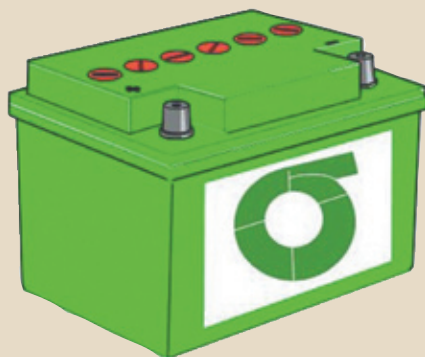
The Green Lead™ Consortium has been developing a series of protocols and guidelines which, if followed, will minimise the risk of lead exposure to people and the environment. By the end of 2005, the consortium had also developed a Green Lead™ assessment tool to help assess facilities anywhere in the LAB life cycle against the Green Lead™ protocols. The assessment tool is being tested at battery manufacturing and recycling facilities in El Salvador, at lead mines, smelters and recyclers in Australia, and battery manufacturers and recyclers in the Philippines.

Additionally, the assessment tool was also tested at the transport links that join the sectors including Mitchell Logistics (road) and Queensland Rail (rail).

Once the testing of the assessment tool has been completed, a Green Lead™ certification scheme and an associated Green Lead™ governance organisation will be established to facilitate third-party verification of performance.

The lead industry's capacity to enhance its contribution to sustainable development rests heavily on its capacity to understand and implement product stewardship principles.

**Once the Green Lead™ program for LABs is in place, the program will be extended to all other uses of lead.**



Source: [www.greenlead.com](http://www.greenlead.com) and Roche & Toyne (2004)

The Fuji Xerox case study shows that in addition to its social and environmental benefits, stewardship makes good business sense. The implementation of this mind shift depends on all participants in the life cycle of a product or service taking direct responsibility for their action and a shared responsibility with customers, suppliers and other participants along the life cycle they are part of. The case study involves the remanufacturing and recycling of photocopier parts. A direct closed loop like this may not be available when there are multiple uses of the company's products, as in the mining industry, although the Green Lead™ example illustrates what is possible in that respect.

### **Case study: Fuji Xerox Australia**

Many readers will be aware that they can hand in their photocopier toner cartridges for recycling, but most would not know that Fuji Xerox Australia (FXA) has been recovering a broad range of used parts and equipment since the 1960s. The company's eco-manufacturing facility in the Sydney suburb of Zetland is a global benchmark operation where used parts or components are restored to 'as new' condition or re-engineered to an even higher standard. A second centre has been opened in Thailand.

Any component that fails in use is subject to failure mode analysis to identify the reasons for the failure. In a related program, opportunities to extend product life depend on signature analysis that helps FXA to determine the remaining life of the part by comparing its 'signature' with that of a new part. Information gained from both these programs is fed back to designer engineers working on the next generation of products. With recycling in mind, asset recovery is a key criterion for product design, taking into account ease of disassembly as well as recyclability of parts and materials.

Although primary manufacturing takes place outside Australia, disassembly and recycling started in Australia. In 1997, more than 2600 machines and 28 000 cartridges were remanufactured by FXA. Eco-manufacturing now supplies 65 per cent (by value) of spare parts and consumables for Australian customers. Approximately 90 per cent of waste generated by the remanufacturing process is recycled, thereby avoiding the need to send 600 tonnes of waste to the landfill each year. By avoiding the purchase of much new material, FXA savings grew from \$8 million in 1996 to an estimated \$25 million in 2000. Customers also benefited from lower prices and elimination of the need to dispose of materials themselves. The company operates a take-back scheme to maximise the impact of its remanufacturing operation.

By 2004, machine recycling was centred in Thailand, where 100 000 cartridges were also recycled or remanufactured for the Australian operation. At Zetland, the eco-manufacturing centre now produces about 300 000 remanufactured parts each year, with the Thai and Australian operations providing remanufactured or recycled products that comprise around 70 per cent of Australia's spare parts. In 2005, Zetland saved the Australian operation \$21 million, grew exports to \$6 million (from \$800 000 in 2001), and diverted 771 tonnes from landfill.

Initially, FXA operated in a market where neither government nor community exerted much pressure for environmental initiatives like remanufacturing and, at first, consumers greeted the remanufactured products with scepticism. However, growing appreciation for the approach, combined with the quality of the products, is helping ensure success for the FXA venture.

More information on this process is available from the web site [www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/xerox-def](http://www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/xerox-def)

'What is good for the environment is good for business', said FXA's then Director Graham Gavanagh-Jones.

### **Eco-efficiency**

For mining and minerals processing, some of the World Business Council for Sustainable Development (WBCSD) eco-efficiency principles can be further elaborated:

- reduce the material intensity of goods and services, this can be achieved through better resource utilisation, reduction of process residues and reduction of water use
- reduce the energy intensity of goods and services, this can be extended to cover reduction of greenhouse gas emissions
- reduce the dispersion of toxic materials, this requires better control of minor elements and toxic materials (WBCSD, 2000; DeSimone and Popoff, 1997).

Eco-efficiency is primarily about 'doing more with less', that is, producing more business value with the same or fewer resources. It is essentially a continuous improvement strategy that can be applied to any industry sector. Table 2 provides some examples of eco-efficiency.

**Table 2: Eco-efficiency examples** (van Berkel, 2005)

Eco-efficiency theme for minerals processing	Example
Effective resource utilisation and materials efficiency	Tiwest introduced synthetic rutile recovery to recover unreacted synthetic rutile and petcoke, and reduce waste generation by 12 tonnes per annum.
Reduction of process residues and enhancement of co-product values	Bluescope Steel installed a Ecocem grinding plant to recover 300 kilotonnes per annum of granulated blast furnace slag for use as a low-grade cement substitute.
Reduction of water use and impacts	Newmont installed a paste thickener to achieve water savings, reduce cyanide loss, improve gold recovery, and improve tailings placement and volume.
Reduction of energylluka consumption and greenhouse gas emissions	Resources installed an innovative waste heat recovery boiler at its rutile plant to generate power and eliminate the need for a conventional air pollution scrubber.
Improved control of minor elements and toxics dispersion	The Alcoa Portland spent pot lining process burns off carbonaceous materials, melts refractory materials into inert slag and recovers fluoride as aluminium fluoride for reuse in smelters.

## 4.2 Resource stewardship



Resource stewardship extends over the lifetime of the resource deposit so that its mining generates maximum benefit. For obvious economic reasons, the primary consideration is to maximise the recovery of the ore and the minerals and metals contained therein. However, stewardship can be extended to other materials that are being moved to mine the ore, such as overburden, vegetation, waste rock, and the co-products contained in the mined ore. Even future use of the landforms and infrastructure created by the project could be considered under resource stewardship.

This approach to resource stewardship in the mining industry is a way of maximising the community and inter-generational benefit of the accumulated natural resources (deposit or field).

Two aspects of resource stewardship may be considered separately making use of part of the resource that would otherwise be wasted and possibly become an environmental contaminant, and producing more product from the resource by improved practices.

### **By-product synergy**

By-product synergies involve the use of by-products previously disposed by one operation that are used as input to another operation, thereby replacing some other business input (van Berkel, 2006).

It is one specific application of what is also known as industrial ecology or industrial symbiosis. The by-product, solid, liquid or gas, could originate from process operations (for example, processing residues and wastes from the manufacturing operations) or from non-process operations such as maintenance, warehousing and administration. The driving force for the resource exchange might be the recovery of specific materials, or the recovery of the energy or water contained in the resource flow.

There are many examples of by-product synergies in the mining and minerals processing industries, in particular in industrial areas with concentrations of minerals processing operations, such as Kwinana (Western Australia) and Gladstone (Queensland) (Bossilkov, 2005). Alcoa uses a by-product from the nearby CSBP chemical operation—gypsum—to assist with plant growth in its Kwinana bauxite residue disposal area. The spent cell linings from the Boyne aluminium smelter in Gladstone, Queensland are used as an alternative fuel for cement making by Cement Australia.

By-product synergies can also be achieved in mining and at individual operations. The Simcoa silicon smelter in Kamberton (Western Australia), for example, uses charcoal as renewable reductant and produces the charcoal on-site using roots and other wood waste generated from the pre-mining clearing in nearby bauxite and mineral sand mines. Sustainability of the smelter operation is enhanced by using roots as a low-grade substitute for mill grade wood to produce charcoal while, from the perspective of the nearby mining operations, resource stewardship is achieved by finding an appropriate use for the roots and other wood waste, which were previously burned on site.

The following case study describes the production of sulfuric acid from sulfur dioxide produced during the smelting of a sulphide ore at Mt Isa, Queensland. The synergy of such processes is widely recognised in the minerals sector but effective implementation usually requires finding a ready market for the acid. If the ore is transported for smelting then acid may be generated in a convenient coastal or industrial location. Where smelting occurs in remote locations, only the proximity of a large industrial user, such as the Southern Cross phosphate fertiliser plant, will make acid production a financially viable operation.

## Case study: Xstrata copper smelter, Mount Isa Mines

Xstrata Copper is demonstrating its commitment to materials stewardship and integration of its operations by:

- increasing recovery of sulfur dioxide (SO<sub>2</sub>) from the copper smelter at Mount Isa Mines and its conversion into acid for use in fertiliser manufacture
- optimising performance of the acid plant thus reducing the need for supplementary sulfur feed
- reducing fugitive SO<sub>2</sub> emissions and making them available for conversion to acid
- utilising a waste from the Townsville Copper Refinery to process electrostatic precipitator (ESP) dust, thereby maximising copper recovery while, at the same time, creating a beneficial use for a waste and integrating downstream processing facilities with the smelter.

Plant optimisation is a key focus for sustainable operation at Xstrata Copper's smelter at Mount Isa Mines. As part of this optimisation process, a strategy to improve copper recovery and capture of SO<sub>2</sub> is being implemented. During 2006, Xstrata Copper is targeting an increase from 80 per cent to 95 per cent capture of SO<sub>2</sub> emissions from the copper smelter. Sulfur dioxide is produced from the smelting of copper-bearing copper concentrate and is used to make sulfuric acid in the adjacent Southern Cross Fertilisers acid plant.

The copper smelter was established in 1953 and has been progressively expanded to produce approximately 240 000 tonnes per annum of copper anode via a process that includes an ISASMELT furnace, a rotary holding furnace (RHF), four Pierce-Smith converters and an anode furnace. In November 2004, capital expenditure of \$41 million was approved to expand the capacity of the copper smelter from 240 000 tonnes per annum to 280 000 tonnes per annum. In addition, in late 2005 a decision was made to increase the copper smelter and refinery capacities to 300 000 tonnes per annum. The copper smelter is located adjacent to the town of Mount Isa, which has a population of around 21 000 residents. Xstrata has an air quality control (AQC) centre, which directs the operation of the company's smelters to ensure emission levels in Mount Isa remain within the company's environmental licence limits.

In September 1999, an acid plant, designed to convert SO<sub>2</sub> emissions from the copper smelter into sulfuric acid, was commissioned at Mount Isa by WMC Fertilisers Pty Ltd. The acid plant is now controlled by Southern Cross Fertilizers.

The strategy Mount Isa Mines is implementing to improve process efficiencies in order to maximise copper recovery and the capture of SO<sub>2</sub> includes the following engineering and administrative improvements.

A gas capture improvement team was established, involving copper smelter and acid plant personnel, as well as AQC staff, to:



- coordinate shutdowns
- discuss process changes
- review gas flows and minimise leaks
- develop a total sulfur balance
- reduce the need to burn sulfur in the acid plant
- improve communications.

It is planned to replace air with oxygen enrichment in the ISASMELT furnace during 2006. By not having to pass atmospheric nitrogen into the smelter, gas volumes will be considerably reduced. This will both increase the SO<sub>2</sub> concentration in process gases to the acid plant, thus giving far better performance, whilst allowing the acid plant to also take gas from other copper smelter processes because there is less demand on acid plant capacity.

Customised design of hooding on the converters will improve capture of low level fugitive gas emissions during converter blowing cycles. This project is part of the improvements to the overall ventilation system to minimise dilution air which consumes acid plant capacity.

Another example of advanced stewardship is the addition of a slag cleaning furnace in 2006, which will enable a slag with reduced copper content to be produced and discarded responsibly without the need for reworking.

Currently, slag with lower metal content than that of concentrate is re-processed to recover the copper content, which takes up more processing time from the copper concentrator and copper smelter and is more energy intensive.

On its way to the acid plant, process off-gas from the opper ISASMELT is passed through an ESP to capture the particulate content known as 'dust'. A new ESP dust leaching plant has been commissioned to recover copper from the dust. This process requires acid to operate and it has been identified that acidic-spent electrolyte from Xstrata's copper refinery in Townsville could supplement acid requirements, rather than be disposed. The by-products from the ESP dust leaching plant are neutralised and fixed in cement as backfill in the copper mine.

Xstrata Copper realises that plant optimisation will provide significant benefits in production and environmental performance. Through good environmental performance, including reducing SO<sub>2</sub> emissions, the company will be able to maintain its social licence to operate. Not only is this of

importance to the local community and customers, it is also important to regulators in potential expansion areas who will examine current practice as a guide to future operations.



**Xstrata copper smelter at Mount Isa Mines—copper smelter (red and white stack) and the acid plant (white stack)**

## Case study: Methane capture and utilisation, Anglo Coal

Deeper coal seams, particularly those consisting of hard coking coal, generally contain significant quantities of methane. Its accumulation in mines, where it was known as 'fire damp', was the cause of many explosions. Safety lamps, of which the most famous was invented by Sir Humphrey Davy, were developed to minimise the danger to miners.

For safety reasons, the Australian coal mining industry has long practiced methane drainage from gassy underground mines.

However, it is now recognised that methane is also a potent greenhouse gas. It has a global warming potential around 21 times greater than carbon dioxide and represents 70 per cent of Anglo Coal Australia's greenhouse gas emissions.

Anglo Coal's methane emissions abatement strategy involves three major activities: improved methane capture, pipeline development and mine site utilisation.

### Improved methane capture

Anglo Coal has extended methane capture with the development and uptake of 'surface to in-seam' drilling techniques that enable the coal seams to be drained of gas from the surface, well in advance of mining. With scope for pre-drainage over many years, this technique improves the recovery and cost efficiency of methane capture. The technology was developed at the company's Dawson (previously known as Moura) Mine in the Bowen Basin coalfield of central Queensland, where it has been used for many years. In-seam drilling has now been extended to Anglo Coal's other underground coking coal mines in central Queensland Capcoal and Moranbah North.

### Pipeline development for methane sales

Access to gas pipelines provides potential for generation of revenue from mine methane, thereby underpinning investment in methane drainage and further reducing fugitive emissions. The early development of methane drainage at Anglo Coal's Dawson Mine gained impetus from access to the nearby Gladstone gas pipeline.

Anglo Coal has also been active for several years in fostering the development of pipeline access for its Moranbah North and Capcoal mines. One pipeline has been constructed providing a market outlet for methane drained by surface to in-seam methods at the Moranbah North Mine.

### Mine-site methane utilisation

If gas pipeline infrastructure is not available, some form of mine site gas utilisation project may be possible. For example, Anglo Coal has entered into an agreement with Energy Developments Limited for construction of a gas-fired power project at its Capcoal mine.

This project will utilise methane drained from underground mining operations for on-site generation of electricity – sufficient to supply a small town. The 32 megawatt project, consisting of 16 reciprocating engines each with two megawatt output, is supported by a Commonwealth Government grant. It will begin operation during the second half of 2006. The greenhouse gas mitigation effect of the power project at full capacity will be 1.2 million tonnes of carbon dioxide equivalent per year, including the effect of displacing the emissions from alternative fuels that would otherwise be used to generate the equivalent amount of electricity supplied to the state grid. That amount of mitigation is equivalent to planting 1.6 million trees or taking 250 000 cars off the roads.

Minimising waste, generating power and cutting back on greenhouse gas emissions is an excellent example of stewardship that benefits the environment and the bottom line.

### **Process innovation**

Process innovation is relevant to resource stewardship where it results in improved metal recovery or enables the useful application of low-grade ores which are not currently economically viable to process.

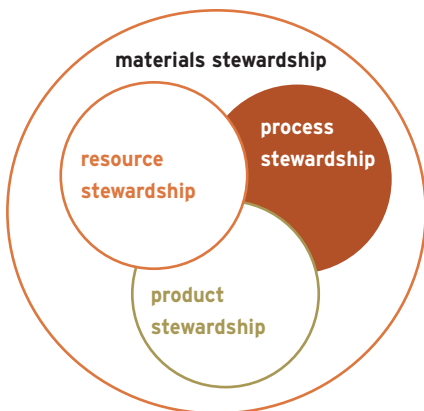
Australia is a signatory to the London Convention (1972) on Prevention of Marine Pollution by Dumping of Wastes and Other Matter and the 1996 Protocol to the Convention which, rather than listing materials that cannot be dumped at sea (as in the original Convention), simply lists seven types of materials that may be so dumped. Further information is available from the web site [www.deh.gov.au/coasts/international/pollution](http://www.deh.gov.au/coasts/international/pollution). For some years prior to this, Pasminco (now Zinifex) had dumped jarosite, a by-product from its zinc refinery at Risdon, Tasmania, and its last permit for this process was issued by the Australian Government in November 1995. Dumping ceased in 1997.

A process change led to the production instead, of an intermediary product, paragoethite, which is transferred for re-treatment at the lead smelter in Port Pirie, South Australia. There, further extraction of metals creates value and the residue is an inert vitreous material (Bossilkov et al., 2005).

In its redevelopment of the Telfer Mine in Western Australia, Newcrest changed the basic outlay of the processing plant from a gold plant to a copper plant, so that gold is now produced as a by-product from copper production from the mined ore. The change enabled higher copper and gold recovery rates, thereby making better use of the intrinsic value of the deposit.

Another example of process innovation can be found in the Hismelt (Rio Tinto) direct reduction iron making technology, which is being demonstrated on a commercial scale in Kwinana, Western Australia. The technology enables production of pig iron from lower quality (high-phosphorous) iron ores and fines that are currently unusable by-products from iron ore mining. The Hismelt plant is also involved in a by-product synergy as it uses low-grade lime kiln dust from Cockburn Cement for its desulfurisation processes, producing a by-product, gypsum, that is used by Cockburn Cement in cement making (Van Beers et al., 2005).

## 4.3 Process Stewardship



In process stewardship, stewardship is extended over the mining operation or processing plant in order to minimise the net environmental impact of the operation and improve economics. This covers the reduced use of process inputs (in particular the reagents energy and water) and the reduced impact on nature through lower waste and emission generation rates and land and biodiversity management. There are many potential economic benefits, such as reduced operating costs due to lower consumption of reagents energy and water and reduced risks and environmental liabilities.

### Utility synergy

Utility synergy involves the shared use of utility infrastructure by different processes, either on the same operation or between operations, such as for the production of energy carriers (for example, power, steam or compressed air), production of process water (such as demineralised water) or for the joint treatment of waste and emissions (such as shared materials recovery facility or wastewater treatment plant) (van Berkel, 2006; Van Beers et al., 2005). The shared utility operation can provide economies of scale by combining smaller by-product streams from several processes or serve the smaller utility demands of several processes. Moreover, utility synergies generally enable specialist operators (such as independent power producers or environmental service companies) to take charge of utility operations, enabling companies to concentrate on their key production processes. Like by-product synergies, utility synergies are an example of the application of industrial ecology or industrial symbiosis (van Berkel, 2006).

Although utility synergies have been pursued within one operation, there has been a growing interest in extending the scope to establish multiple company utility synergies, particularly in areas with concentrations of minerals processing operations, such as Kwinana in Western Australia, and Gladstone in Queensland (Bossilkov et al., 2005). For example, Queensland Alumina now takes secondary treated effluent from the nearby waste water treatment plant as 'fit-for-purpose' water for its final red mud washing operation, thereby substituting up to 6.5 megalitres per day scheme water in the Gladstone area. Many similar ventures have been documented in agriculture and industry, including the provision of cooling water to BP's Brisbane refinery from the nearby sewage works. There is a growing practice of using treated waste water in the industry. In Kwinana, the Tiwest pigment plant collaborated with Verve Energy to establish a cogeneration plant, which provides a reliable and cost-effective source of high-pressure steam and electricity for the pigment producer.

The case study below derives from a single operation in Queensland, the optimisation of the QNI Yabulu nickel refinery.

Three projects were included to achieve energy and water synergies—the use of cool boiler feed water to condense still off-gases; green water reuse in the nickel thickener circuit; and cobalt plant water reuse. Collectively these measures reduced the specific energy consumption by 2.6 per cent, specific water use by 9.8 per cent, and greenhouse gas intensity by 2.3 per cent. Moreover, they reduced annual operating costs by about \$4 million (UNEP Cleaner Production Centre, University of Queensland, 2004).

### Case study: Yabulu

Queensland Nickel (QNI), a BHP Billiton company, is a leading example of an organisation heading towards sustainable minerals processing in Australia. It operates a nickel refinery at Yabulu, 25 kilometres north of Townsville, Queensland, where it refines laterite ore into 30 000 tonnes per annum of nickel (as nickel metal and oxide) and 2 000 tonnes per annum of cobalt. The company sells both to produce stainless and speciality steels, alloys and chemicals.

Since 2001, QNI has been working to implement the Yabulu Optimisation Initiative, which focuses on increasing the quantity of nickel and cobalt produced per tonne of fuel, water and ore input to the processing plant. In 2003, three projects were commissioned to address energy and water reuse while increasing cobalt recovery. Relevant environmental performance indicators are reported as part of the QNI and BHP Billiton Annual HSEC Reports. Case study details are available from the web site [www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/nickel-refinery.html](http://www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/nickel-refinery.html).

The refining process uses water from the local bore field and from a dam in the Mt Spec National Park, located to the north of the plant. The projects have reduced the quantity of new water used in the process by 20.3 kilolitres per tonne. Given the level of production of nickel and cobalt, this represents a substantial reduction in overall water use. As well, the quantity of energy used per tonne of product has been reduced from 583 gigajoules per tonne by 16 gigajoules per tonne, and the plant's greenhouse gas emissions have been reduced from 46.5 tonnes carbon dioxide-equivalent per tonne of final product to 45.4 tonnes. The following changes led to these significant savings:

- Heat from a hot stream of off-gas (consisting of ammonia, carbon dioxide and water vapour) is now used to preheat boiler feed water.
- The water (1.3 megalitres per day at approximately 85°C) that is removed from a slurry of green-coloured basic nickel carbonate in a thickener, and that formerly found its way to the tailings pond, is now used to preheat the nickel liquor stream at an earlier point. It is then cooled in the pond and pumped to the process water tank for reuse.
- Hot water (an average 0.35 megalitres per day) from the cobalt plant where cobalt oxide hydroxide is formed was formerly discharged to the tailings dam, constituting a waste of both heat and water. Now it is used to replace new water used at an earlier stage of the cobalt process.

The QNI experience shows how projects that benefit the environment can also have a sound economic benefit, since by practicing this stewardship the company achieved a saving of \$3.8 million per annum.

### **Plant optimisation**

Plant optimisation is relevant for process stewardship where it results in higher plant efficiencies, lower emission levels, or reduced risks to workers, the community and the environment. Particularly promising are process intensification (achieving higher process throughput with the same process volume or size of unit operations) and process integration (achieving two or more process steps in one unit operation). Applied to mining and minerals processing, plant optimisation can be understood as sustainable or eco-efficient plant design (van Berkel, 2004; Twigge-Molecey, 2004).

Plant optimisation is typically a continuous improvement process, with more significant opportunities arising as part of capacity expansion or efficiency upgrade projects (brown-field projects).

### **Case study: Pinjarra alumina refinery**

The recent efficiency upgrade at Alcoa's Pinjarra alumina refinery demonstrates the benefits of leading practice technology transfer and community engagement.

The upgrade increased refinery capacity by 657 000 tonnes to 4.2 million tonnes per annum of alumina, while delivering significant environmental and social benefits. It involved leading practice technology transfer to improve productivity and energy efficiency, including from Alcoa's Wagerup refinery and global operations.

Key project components included:

- Process and utilities flow: maximising energy recovery, including recovery of vapour from digestion to causticiser (requiring one kilometre of insulated steam pipeline for an annual greenhouse gas emission reduction of about 250 000 tonnes carbon dioxide-equivalent) and several synergies with regard to process bundling requirements.
- Transfer of best practice technology: inclusion of seed precipitation in the Bayer circuit (to increase alumina recovery in precipitation); construction of an additional energy efficient calciner (approximately five per cent reduction of energy use) and of two energy efficient regenerative thermal oxidisers (one for volatile organic compounds control and one on the oxalate kiln).
- Engineering design: a wide range of enhancements in pumping and process controls throughout all parts of the major Bayer circuit and modification, refurbishing and re-engineering a previously used 450 tonnes per hour bauxite mill to increase bauxite grinding and capacity.

Additional energy and greenhouse benefits are being achieved by co-locating Alinta cogeneration plants (an example of utility synergy). The plants produce electricity and heat from the same fuel source, delivering greenhouse benefits. Alcoa will use the steam, while Alinta will sell electricity into the grid.

A year's electricity from each cogeneration unit saves around 450 000 tonnes of greenhouse gas emissions compared with a similar sized coal fired plant. In addition, each unit will reduce Alcoa's refinery emissions by 135 000 tonnes per year through more efficient steam generation.

The project involved extensive community consultation with direct community input into all stages of the project. A key objective was to maximise potential benefits to the region through local contracts and employment. Around 1500 contractors worked on the Pinjarra upgrade in 2005 and the project has been described by the Western Australia Environmental Protection Authority as a best practice example of public engagement.



**This cogeneration power plant at the Pinjarra refinery will reduce the refinery's greenhouse emissions by 135 000 tonnes a year.**



**The refinery's greenhouse intensity will be reduced by eight per cent through cogeneration and other energy efficiency improvements in the Pinjarra upgrade project.**

## **Cleaner production**

Cleaner production is generally defined as the continuous application of an integrated preventive environmental strategy to processes, products and services which aims to increase eco-efficiency and reduce risks to humans and the environment (ANZECC, 1998; Environment Australia, 2000).

Cleaner production aims at progressively reducing the environmental impacts of processes, products and services, through preventative approaches rather than control and management of pollutants and wastes once these have been created. It addresses economic and ecological efficiency, and helps reduce risks to the environment.

Cleaner production aims at making more efficient use of natural resources (raw materials, energy and water) and reducing the generation of wastes and emissions at their source. This is generally achieved through combinations of product modification, input substitution, technology modification, good housekeeping and (onsite) recycling and reuse (USEPA, 1992).

The table below contains examples of how these five prevention practices can be applied to mining and minerals processing (van Berkel, 2002).



**Table 3: Cleaner production practices applied for mining and minerals processing**

Prevention Practice	Applications	
	Mining	Minerals processing
1. Resource use optimisation	<ul style="list-style-type: none"> <li>Better separation of overburden and other wastes to produce higher purity ore.</li> </ul>	<ul style="list-style-type: none"> <li>Sequential leaching to recover multiple minerals/metals from ore</li> <li>Conversion of wastes and emissions into useful by-products</li> <li>Processing residues into geo-chemically stable forms for safe storage.</li> </ul>
2. Input substitution	<ul style="list-style-type: none"> <li>Use of biodegradable lubricants and hydraulic oils.</li> </ul>	<ul style="list-style-type: none"> <li>Using environmentally-friendly reagents and process auxiliaries.</li> </ul>
3. Technology modification	<ul style="list-style-type: none"> <li>Designing mines for efficiency to minimise materials movement during operation and closure</li> <li>Pit wall steepening</li> <li>In pit milling and separation.</li> </ul>	<ul style="list-style-type: none"> <li>Using alternative metallurgical processes (such as bio-leaching)</li> <li>Using of energy efficient motors</li> <li>Installing fuel efficient furnaces and boilers</li> <li>Better monitoring and control of leaching and recovery processes, to increase overall recovery.</li> </ul>
4. Good housekeeping	<ul style="list-style-type: none"> <li>Monitoring and benchmarking of haulage fleet fuel efficiency</li> <li>Staff training and awareness</li> <li>Spill and leak prevention, such as for hydrocarbons (fuel, lubricants, hydraulic oils).</li> </ul>	<ul style="list-style-type: none"> <li>Improving staff training and awareness</li> <li>Preventing spills and leaks, such as for hydraulic oil, compressed air, water, chemicals.</li> </ul>
5. On site recycling	<ul style="list-style-type: none"> <li>Composting or heat/steam generation from site clearing green wastes</li> <li>Reuse of overburden/waste rock in progressive rehabilitation of mine-sites.</li> </ul>	<ul style="list-style-type: none"> <li>Recovering and reprocessing of unreacted ore from processing waste</li> <li>Counter-current use of water for washing operations.</li> </ul>

**Table 4: Enduring Value elements for cleaner production**

ICMM Principle/ guidance element	Description
<b>Principle 8</b>	<b>Facilitate and encourage responsible product design, use, reuse, recycling and disposal of our products.</b>
<b>Element 8.2</b>	Conduct or support research and innovation that promotes the use of products and technologies that are safe and efficient in their use of energy, natural resources and other materials.
	Where appropriate support research to improve eco-efficiency of production processes and products.
	Review and innovate to reduce waste through cleaner production processes, recycling and reuse of materials.
	Review usage and innovate to improve efficiency in the use of energy and water.
	Take other users' present and future requirements into account, including air and water quality and environmental flows of water.
	Involve suppliers identifying opportunities to reduce energy consumption or use renewable sources to reduce production of greenhouse gases and other emissions.
	Where feasible, collaborate in industrial ecology activities to develop synergies in resource usage (see elements 1.4, 2.4, 4.1, 6.1, 7.2, 7.3, 8.3).

## Case study: Port Kembla sinter machine emission reduction plant

The opening of the sinter machine emissions reduction plant in September 2004 represented a \$94 million investment in cleaner air for employees and neighbours of BlueScope Steel's Port Kembla Steelworks. The project is an example of the company's commitment to improve environmental conditions in and around the steelworks.

At the sinter plant, fine particles of coke, iron ore and limestone, and recycled iron-bearing dusts, are burnt to make sinter, which is used in the ironmaking process. The gas released through the sinter plant stack contains fine dust particles and trace levels of dioxins.

Following an extensive worldwide search to identify a technology to address dust and dioxin emissions from the sinter plant, BlueScope Steel selected the technology developed by Sumitomo Heavy Industries of Japan.

The technology employs a carbon-packed bed filter which uses activated char granules to filter dust from the waste gas stream. The activated char adsorbs dioxins, sulfur dioxide, sulfur trioxide and heavy metals. The char is later regenerated (re-activated) at high temperature, which destroys the dioxins.

Prior to installing the gas cleaning plant, dust in the waste gas stream was around 80-100 milligrams per normal cubic metre and dioxin levels were at around three nanograms per normal cubic metre of waste gas (one nanogram is one-billionth of a gram; a grain of sand weighs around 300 000 nanograms).



Tests to date indicate the plant is achieving its target of less than 20 milligrams of dust per normal cubic metre (an 80 per cent reduction), and improving on the dioxin target of 0.3 nanograms per normal cubic metre (achieving a reduction nearing 97 per cent).

The upgrade has reduced both dust levels and dioxin emissions, virtually eliminating the single biggest plume from the Port Kembla Steelworks.

## 4.4 Product stewardship

Product stewardship focuses on the consumer goods and other end-products that are produced from mineral ores and concentrates. It focuses on the environmental



aspects of the product or service, including the systems and processes necessary for its raw material sourcing, manufacture, distribution, consumption, service and repair, and end-of-life management. Its primary aim is to minimise the net environmental impact per unit of product functionality to the end consumer. Normally, product stewardship considers multiple environmental impacts; some are associated with the use of materials, energy, water and auxiliaries, and others are associated with the release of waste and emissions to air and water from the product system.

As most mining and mineral processing companies do not integrate product manufacture into their businesses, there is less focus on this approach within the mining industry. However, the advent of holistic stewardship programs such as life cycle assessment (LCA) has fostered a greater interest in this approach, particularly in terms of how the mining industry differentiates its products and services to maximise value and safeguard market access. LCA is the primary analytical tool to inform product stewardship. The fundamentals of LCA were discussed in Section 3. Additional information can be found in the reference section.

The business case for implementing product stewardship policies include:

- improving product differentiation in the marketplace
- branding of pro-actively disseminated product management information for all users
- maintaining market access
- maximising opportunities for recycling and reuse
- foregoing the need for additional regulation.

When focusing on the business case for product stewardship, practitioners need to be mindful that a business-case focus in developing a product-centred scheme could weight issues very differently to the risk-based approach commonly employed in resource and process stewardship. The main issues of concern for consumers are driven by the media representation of issues, rather than analyses of actual risk. In addition to the consumer concerns, product stewardship schemes need to focus on communicating the total level of risk from an operation and how this risk is being managed, as well as information on how to safely manage products.

## Case study: Information provision—role of GLASS

A non-government organisation, The LEAD Group, founded in Australia in 1991, has in the past 15 years developed advocacy systems involving regulators, industry and the wider community aimed at lead abatement. The LEAD Group runs the unique-in-the-world, free-to-users Global Lead Advice and Support Service (GLASS).

GLASS provides information, advice, counselling and referrals in relation to the management and prevention of lead poisoning and lead contamination. GLASS can refer callers to community or other groups, specialist tradespeople and organisations, as required. GLASS also provides information through The LEAD Group web site and maintains a database, including a library database.

GLASS has provided lead poisoning/contamination prevention and management advice directly. It has received such information in its capacity as an information clearing house in more than 48 500 calls from over 80 countries and provided web-published information for more than one third of a million visitors from 175 countries.

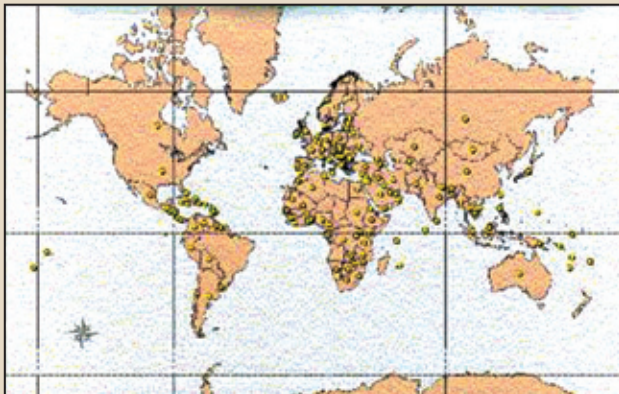
GLASS currently runs nine e-groups covering a range of lead-related topics; with more than 280 members, the largest e-group is for parents of lead-poisoned children with autism. GLASS has written and published on the internet more than 30 different fact sheets covering topics ranging from state codes of practice for lead to lead in breast milk. GLASS has distributed more than 680 000 library items in 16 languages since 1995. The GLASS database has more than 4 700 listed experts for referrals in medical, environmental and other lead-related fields.

GLASS has been funded through corporate sponsorship, government grant and private donations. Due to funding constraints, GLASS extensively utilises volunteers for its day-to-day operations. It has 23 active volunteers who log phone calls, research responses to complicated enquiries, keep the web site and library up-to-date, manage the accounts, and carry out systems administration and special projects. University interns are engaged to do short-term projects, such as the product stewardship of Australian lead by a Sydney University student.

The World Health Organisation (WHO) estimated that in 2 000 there were 120 million people with lead levels (in blood) above 10 micrograms per decilitre (WHO, 2003). The US Center for Disease Control and Prevention recommends a maximum of 10 micrograms of lead per decilitre of blood in children under five years old. Clearly, reliable access to information and assistance is critical to ensure prevention and management advice is available to all affected persons.

Through the data collected by GLASS, The LEAD Group provides focus on lead issues using data and trend analysis to monitor the effectiveness of change initiatives over time. In this age of information, provision of information through the efforts of NGOs, governments and industry could find wider applications.

Further information can be found in the publication *Lead Mining Stewardship Grey Lead and the Role of GLASS* from the web site [www.lead.org.au/fs/fst31.html](http://www.lead.org.au/fs/fst31.html).



**Over one third of a million visitors from 176 countries have sought lead management information from The LEAD Group's website**  
[www.lead.org.au](http://www.lead.org.au).

Leading practices for product stewardship include green procurement, design for environment, and environmental disclosure. In practice, however, elements of these are often combined to achieve an effective product stewardship program.

### **Green procurement**

In essence, green procurement involves the inclusion of environmental considerations or requirements in the sourcing of business inputs. Such inputs include engineering; maintenance and transport services; mining and process equipment; energy and fuels; and consumables such as lubricants, cleaners and reagents. Green procurement is sometimes referred to in a broader context as 'greening of the supply chain'.

The New Zealand Business Council for Sustainable Development (NZ BCSD) has developed a practical guide for a 'sustainable supply chain', which they define as 'the management of raw materials and services from supplier to manufacturer/service provider to customer and back with improvement of the social and environmental impacts explicitly considered' (NZ BCSD, 2003).

It focuses on three areas—procurement (monitoring the goods and services sourced from external suppliers), internal operations (the impact of logistics and conversion processes from raw materials through to the customer and back again), and product development and stewardship (working effectively with customers and sales channels).

Achieving practical green procurement requires consideration of the nature of the supply. In some cases, it may be possible to enforce specific performance levels (for example, energy and water efficiency of process equipment and haulage fleet).

In other cases, it may be more appropriate to enforce a specified level of environmental management performance on the supplier by establishing a certified environmental management system (now quite common among major automobile and electronics manufacturers); or insisting that service providers comply with the purchasing company's own environmental standards and policies (now widely accepted for engineering and maintenance contractors). In other situations, it may be more appropriate to work in collaboration with suppliers or customers to develop a set of best practices (similar to what was done with shipping service providers to major mining companies).

The mining industry is heavily reliant on ships to transport its products around the world. The integrity of ships is, therefore, critical as many of them pass through areas of world heritage or environment significance, such as the Great Barrier Reef, Cockburn Sound and the approaches to Gladstone.

The case study on RightShip exemplifies an industry approach to this situation. Vessels used to transport mineral products are vetted across a range of performance criteria before they are engaged.

### **Case study: RIGHTSHIP**

Rio Tinto and BHP Billiton seek best practice stewardship in their own operations and throughout the product supply chain, making sure that products are stored and transported in safe, environmentally sound ways.

With Rio Tinto and BHP Billiton transporting millions of tonnes of product by sea to customers each year, shipping is a key focus for them. For many years, both companies have invested heavily in ship vetting processes to gather information, check the quality of ships nominated to carry cargoes and minimise shipping risk.

In 2001, the two companies combined their considerable vetting expertise to form RightShip Pty Ltd (a 50:50 owned company between BHP Billiton and Rio Tinto). As a specialist vetting company, RightShip offers a uniquely comprehensive online system, backed up by a global network of vetting experts offering advice and providing enhanced services.

RightShip vets every ship that Rio Tinto and BHP Billiton use to move their cargoes.

Each time a ship is nominated, it appears in the online system and its suitability for the task is evaluated against more than 40 criteria, covering the ship's structural integrity, history and the competence of its owners, managers and crew.

The ship is immediately rated acceptable or highlighted as requiring further review. It is a vital decision support tool, delivering critical information immediately to assist fast, appropriate decision-making.

Rio Tinto and BHP Billiton identified the need for such a system when the global shipping industry experienced unacceptable human, environmental

and financial losses. Dry bulk shippers were plagued by ageing, poor quality ships. During 1990 to 2 000, 730 seafarers died, 160 vessels were lost, and 888 serious casualties and 2 879 minor casualties occurred.

As two of the largest shippers of dry bulk products, Rio Tinto and BHP Billiton needed to manage their own risk. As commercial competitors, this union may have seemed odd, but they had common goals. Both companies wanted to manage their own risk effectively and efficiently and eliminate sub-standard ships and operators from the industry, to ensure companies with quality ships and crews would not continue to suffer commercial disadvantage.

To increase pressure on high-risk ships and operators, RightShip makes its valuable expertise available to anyone seeking vetting support. RightShip now serves more than 50 client organisations. In 2005, RightShip vetted 9 162 ships online, representing about 827 million deadweight tonnes of cargo; inspected and assessed 431 ships; and excluded 165 high risk ships from clients' supply chains.

RightShip's influence can also be seen through its global customer base, with clients in 45 countries. RightShip illustrates appropriate stewardship, as Rio Tinto and BHP Billiton have invested significantly in managing risk and protecting vital human and environmental resources for the benefit of their own operations and to influence broader improvement in the industry.

The key lessons from RightShip's success are about:

- identifying an urgent need and developing an innovative and uniquely valuable response
- thinking broadly to maximise impact and seeking alliances based on common interests, even among commercial competitors
- giving passionate, expert people the resources to build on innovative ideas and keep improving their application, within the company and in alliance with others.



**Bauxite shipment to Alumina Refinery (Rio Tinto Aluminium Limited), Gladstone, Queensland**



## Design for environment

Design for environment, sometimes called eco-design, eco-redesign or life cycle design, is an approach that encourages businesses to give greater thought to the design of products to minimise their environmental impacts, while increasing market advantage and fostering innovation (Environment Australia, 2001). In practical terms, design for environment means that the 'environment' helps to define the directions of the design decisions (Brezet et al., 1997). In other words, the environment becomes a co-pilot in product development. In this process, the environment has the same status as more traditional industrial values, such as profit, functionality, aesthetics, ergonomics, image and overall quality. As a result, environmental attributes are improved while enhancing the attributes of the product. The principles of design for environment are simple and its implementation is, in principle, achievable for businesses of all sizes.

There are three elements that are critical to the success of any design for environment initiative:

- systematic design and product development
- life cycle thinking
- eco-design strategies.

Several sets of generic eco-design strategies already exist. For example, the United Nations Environment Program (UNEP) promotes an approach involving eight strategies (Brezet et al., 1997):

- developing new concepts of product functionality
- choosing low impact materials
- reducing the usage of materials
- optimising production techniques
- optimising distribution system
- reducing impact during use
- optimising initial lifetime management
- optimising end-of-life management.

Further customisation of such strategies to specific industry sectors or product categories is generally beneficial. However, in most cases, mining and minerals companies will contribute to the design for environment initiatives of their customers, those who use primary minerals and metals to produce cars, electronics and so on, rather than undertake these on their own behalf.

## Case study: steel building materials

The built environment (buildings and infrastructure) represents about half the material flows in the Australian economy. Compared with Australian totals, it is estimated that buildings use 30 per cent of raw materials, 42 per cent of energy and 25 per cent fresh water and are responsible for 40 per cent of atmospheric emissions, 20 per cent of water effluents and 25 per cent of solid waste. The built environment represents the most important part of the life cycle for many mineral and metal materials and, therefore, the most important stewardship challenges and opportunities. This is certainly the case for steel, where residential and commercial buildings alone account for an estimated 33 per cent of steel consumption in Australia, before considering mining, engineering and civil infrastructure.

The industry has a proven track record in improving the life cycle environmental performance of steel materials and buildings through eco-efficient production, recycling and the smart design of building systems using steel.

Energy and greenhouse gas intensity of steel production have decreased by around 40 per cent over the past 25 years through persistent improvement and the introduction of continuous casting. Fresh water use has been roughly halved over the past decade. Currently around 70 per cent of the main process residues (slags) are sold for use in cement blends and as construction aggregate; the remainder are stored on site, not sent to landfill. The recovery rate for scrap steel building materials is very high, around 85 per cent.

The recovered steel is recycled through the basic oxygen and electric arc steelmaking processes or in some cases reused directly without remelting.

Innovation in the design of building systems that leverage the special qualities of steel is considered the most fertile area for future advance.

Good functional, aesthetic and environmental design can leverage the intrinsic qualities of steel, such as strength to weight ratio, surface coatings, weldability and flexible fabrication/dismantling techniques, as shown in the photographs provided by OneSteel and BlueScope Steel. Extending the useful life and value of materials and buildings greatly improves their life cycle environmental impacts.

In highlighting steel's potential to contribute to building designs with improved overall life cycle environmental performance, there is no intention to imply that steel is 'better' than other building materials, such as timber, concrete or aluminium. All materials have their distinctive properties and advantages in particular circumstances. Environmental impact comparisons between different materials need to consider the value that is being created, the function that is being fulfilled, the need that is being addressed and the aesthetics for particular applications.

Stewardship with a simultaneous emphasis on value creation in the market place and impact reduction throughout the steel life cycle and, more importantly, the building as a whole, can become a powerful business driver affecting operations and market relevance.

For more information and references to this case study, see Strezov, L & Herbertson, J 2006, Life cycle performance of steel in the built environment, The Crucible, Australian Steel Institute.



### **Lighter structures**

The lighter steel frame for the Latitude @ World Square building in Sydney, New South Wales, allowed more floor area to be built for the same structural mass with significantly reduced strengthening costs and building foundation footprint.



### **Flexible upgrading**

Existing steelwork at Chiffley Tower, Sydney, was modified to accommodate a new and more efficient air conditioning system and the addition of internal stairs reduced the reliance on lifts.



### **Building on material value**

Lighter steel frame at 347 Kent Street, Sydney, allowed eight levels to be added to the existing 15 level building while still tenanted and functioning with around 1000 people.

Lighter steel frame reduced strengthening requirements by greater than 50 per cent.

New floors attract higher rent income, since they have better views.



### **Design for reuse**

Whole steel structures such as stadium seating may be used for another purpose at another location. A good example is part of the Aquatic Centre in Sydney, which was demounted after the closing ceremony of the Olympics and relocated to WIN Stadium in Wollongong.

## Environmental disclosure

Demonstrating stewardship achievements is conditional on transparency and accountability on environmental and possibly social performance. The trend towards corporate sustainable development reporting and standardisation through such projects as the Global Reporting Initiative is a promising sign that mining and minerals companies accept their accountability not only to shareholders, but to broader community stakeholders. However, for successful stewardship initiatives, the aggregated reporting at corporate or even business unit or commodity level may not be sufficient.

There has been a plethora of disclosure approaches. The most detailed information comes from life cycle assessment studies and could be translated in environmental product declarations or environmental labelling schemes. An alternative, less quantitative approach, involves the establishment of codes of conduct or good practices, which can be externally verified, for example in the Green Lead™ case study.

In Europe the approach most likely to be followed is set out in the European Commission's Green Paper on *Integrated Product Policy* available on the web site [www.europa.eu.int/comm/environment/ipp/home.htm](http://www.europa.eu.int/comm/environment/ipp/home.htm) . Under the heading 'tools and incentives to strengthen business leadership in greener production', the commission calls for an increase in 'the availability, user-orientation and leverage in the market of accurate non-misleading information' and says that the first step would need to be the generation and collection of such information. Initiatives have been developed for end-of-life management of vehicles, energy using processes, waste electrical and electronic equipment, packaging, batteries, and direct or junk mail.

Industry needs to look at how to better integrate environment aspects in the design of products while consumers can assess how they can purchase greener products and how they can better use and dispose of them. More information can be found on the web site [www.dti.gov.uk/sustainability/IPP.htm](http://www.dti.gov.uk/sustainability/IPP.htm) .

A leading life cycle approach to the communication of the potential impacts around production involves the development of environment product declarations.

### Case study: Environment product declarations

The Rio Tinto business unit, Kennecott Utah Copper Corporation, operates the Bingham Canyon Mine, about 25 miles south-west of Salt Lake City in the American state of Utah. The ore body consists mainly of metal sulphides with trace precious metals. Annually, the mine produces approximately 250 000 tonnes of copper, 15 000 tonnes of molybdenum (metal), 850 000 tonnes sulfuric acid, and by-products gold (300 000 troy ounces) and silver (3.3 million troy ounces).

The company believes that 'sustainable development is integral to our survival as a mining, smelting and refining company'. It regards its stewardship performance as 'essential to delivering value on the social and financial investment' that stakeholders and surrounding communities have made in it.

In pursuit of this aim, the company has performed life cycle assessments consistent with the ISO 14040 standards for each of the three major products of its Bingham Canyon operations. Each assessment makes clear what it excludes—capital equipment, off-site administrative facilities, and transportation of finished products off site—and what it includes. Among the inclusions are key operations such as ore and overburden mining, extraction and processing of materials, packaging, power generation, and waste management (on and off site).

The initial operations are the same for each of the three assessments. They include drilling, blasting, loading, hauling, crushing, conveying, grinding and flotation. Explicit consideration is then given to the inputs to each unit's operation. These include water, a range of energy sources, explosive materials such as ammonium nitrate, process materials including steel bits and rubber tyres, nitrogen and oxygen gases, and chemicals ranging from specialties such as flocculants to basics like caustic soda. Outputs include emissions to air of particulate matter and oxides of carbon, nitrogen and sulfur, and movement to tailings impoundments of insoluble rock particles and solutions of iron, strontium, lead, manganese and other metals.

The flotation process separates the molybdenum and copper sulphides, which are then smelted in separate roasters. The resulting molybdenum oxide is shipped off site for refining, and the crude copper undergoes electrolysis to refine it to a metal of 99.99 per cent purity. The sulfur dioxide flowing from the roasters is oxidised catalytically by the contact process to yield sulfuric acid. About 93 per cent of the sulfur that started as molybdenum sulphide or the copper-iron sulphide, chalcopyrite, is captured in this way. As well as greatly reducing the release of environmentally unfriendly acid gases, the formation of sulfuric acid provides an industrial chemical that finds ready markets in a range of industries.

Every step in these three product streams is analysed for its input of energy and materials, as described above, and for the release of greenhouse gases and



air pollutants such as acid gases and volatile organic compounds (VOCs) which contribute to formation of photochemical smog. The company publishes the results of this work around its products as Environment Product Declarations which it supplies to customers and other interested stakeholders.

**Mining operations at Kennecott's Bingham Canyon mine**

Table 5 lists some of the elements of Enduring Value which can be used as a checklist for product stewardship.

**Table 5: Elements of Enduring Value for product stewardship checklist**

ICMM Principle/ Guidance Element	Description
<b>Principle 2</b>	<b>Integrate sustainable development considerations within the corporate decision-making process.</b>
<b>Element 2.4</b>	Encourage customers, business partners and suppliers of goods and services to adopt principles and practices that are comparable to our own.
<b>Guidance</b>	Implement a procurement policy that includes sustainable development performance outcomes in key contracts (see elements 1.4, 2.4, 6.4, 8.2-8.5).
	Promote product stewardship initiatives throughout the supply chain through partnerships with contractors, suppliers and customers (see elements 1.4, 8.1-8.5).
	Encourage customers, contractors, suppliers and business partners to adopt sustainable development policies and practices.
	Establish 'suppliers of choice' which include sustainable development criteria, such as the role of local employment, service and supply to foster local economies (See elements 1.4, 8.1-8.5).
<b>Principle 8</b>	<b>Facilitate and encourage responsible product design, use, reuse, recycling and disposal of our products.</b>
<b>Element 8.3</b>	Develop and promote the concept of integrated materials management throughout the metals and minerals life cycle.
<b>Guidance</b>	Track business inputs and outputs in a communicable and reportable format.
	Promote safe handling, storage and use of materials throughout the supply chain
	Inform customers about the safe and responsible use of mineral products and options for their reuse (see element 2.4).
	Develop preferred safe and responsible suppliers of materials and resources (see element 2.4).
<b>Element 8.4</b>	Provide regulators and other stakeholders with scientifically sound data and analysis regarding our products and operations as a basis for regulatory decisions.

<b>Guidance</b>	Understand the precautionary principle and its application in policy development; and integrate this understanding into planning, design and the cycle of management review (see elements 1.3 and 2.1).
	As appropriate, provide regulators and the scientific community with scientific and technical advice about our products and operations, including the outcomes of site-based monitoring (see elements 1.4, 4.1, 6.4, 7.2-7.3, 10.1-10.3).
	Collaborate in research on life cycle impacts of processes, products and by-products as appropriate (see elements 2.4, 4.1, 6.3, 7.2-7.3, 10.3).
	Encourage collaboration between government, industry and the scientific community in research and demonstration programs to foster improved science and informed policy development (see elements 1.4, 4.1, 6.4, 7.2-7.3, 10.1-10.3).
<b>Element 8.5</b>	Support the development of scientifically sound policies, regulations, product standards and material choice decisions that encourage the safe use of mineral products.
<b>Guidance</b>	<p>At industry, company, site and supply chain level, participate in creating and sharing knowledge about relevant disciplines such as:</p> <ul style="list-style-type: none"> <li>• materials handling regulations, standards or requirements</li> <li>• management of hazardous substances</li> <li>• risk assessment and identification</li> <li>• controls on the selection of materials</li> <li>• establishment and regulation of product standards.</li> </ul> <p>At industry, company, site and supply chain level, participate constructively in policy development in relevant jurisdictions (see elements 1.4, 4.1, 6.4, 8.4, 10.1-10.3).</p>



## 5.0 CONCLUSION

Stewardship has become the mantra of the modern industrial age. That is to say, there is broad agreement that stewardship is the appropriate response to manage the potential harm to human health and the environment, and to efficient use of resources. It would be difficult to disagree with this position, but we all have our own definition of what stewardship means to us and what we believe it should mean to others.

Implicit to stewardship is the need and opportunity to act beyond traditional business boundaries, since the objective is improving economic, environmental and social performance around whole value chains and life cycles. Finding ways to stimulate systems thinking and promote innovation beyond one's direct sphere of control, while maintaining one's own business purpose and viability, is a cultural challenge for many organisations. Innovation in the ways we operate and think about our businesses is the challenge and the opportunity at the heart of implementing stewardship successfully.

There is growing worldwide support for the concept of stewardship and it covers all aspects of industry and each element in the chain of activities that connect resource extraction through processing and manufacture, to use and the eventual post-consumer fate of materials. By reducing the risk of harm, stewardship is good for society. Likewise, resource conservation and efficient use makes good sense and is, moreover, good business, as many companies have found. The minerals sector has been a leader in applying the principles of stewardship to its activities and the benefits to business and society are already evident.

The intrinsic support for stewardship has a number of drivers. These range from environment and community groups, often congregated around a version of the precautionary principle, through government regulators and businesses themselves. The chains of influence that result can be extraordinarily powerful in driving the uptake of stewardship principles and practices. Therefore, a manufacturing company may specify that it will only purchase from a supplier, perhaps a minerals processing firm, if the supplier attains an agreed level of stewardship in its own business. This behaviour can be repeated down the chain as consumers express their preferences and recyclers demand segregation of wastes before they can be efficiently collected. The view down the chain is also enhanced by suppliers who refuse to supply customers unless certain guarantees of responsible use are in place.

The mining industry, indeed, any industry group, is often judged by the public on the basis of its worst performers. This handbook showcases some of the excellent work undertaken by the mining industry in applying the principles of stewardship. Australian and some international case studies are presented, because this is truly a global industry, in which Australian companies are major participants.



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## WEB SITES

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- Australasian Institute of Mining and Metallurgy - [www.ausimm.com.au/](http://www.ausimm.com.au/)
- Basel Convention on Hazardous Materials [www.basel.int/](http://www.basel.int/)
- Centre for Sustainable Resource Processing [www.csrp.com.au](http://www.csrp.com.au)
- Department of Industry, Tourism & Resources [www.industry.gov.au](http://www.industry.gov.au)
- Leading Practice Sustainable Development Program  
[www.industry.gov.au/sdmining](http://www.industry.gov.au/sdmining)
- Ministerial Council on Mineral and Petroleum Resources  
[www.industry.gov.au/resources/mcmpr](http://www.industry.gov.au/resources/mcmpr)
- Department of the Environment and Heritage [www.deh.gov.au](http://www.deh.gov.au)
- Green Lead [www.greenlead.com](http://www.greenlead.com)
- International Council on Mining & Metals [www.icmm.com](http://www.icmm.com)
- ICMM Sustainable Development Principles [www.icmm.com/icmm\\_principles.php](http://www.icmm.com/icmm_principles.php)
- International Cyanide Management Code [www.cyanidecode.org](http://www.cyanidecode.org)
- Minerals Council of Australia [www.minerals.org.au](http://www.minerals.org.au)
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- Responsible Jewellery [www.responsiblejewellery.com/](http://www.responsiblejewellery.com/)
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- Responsible Mining [www.responsiblemining.net/](http://www.responsiblemining.net/)
- Rotterdam Convention [www.pic.int](http://www.pic.int)
- Strategic Approach to International Chemicals Management  
[www.chem.unep.ch/saicm/](http://www.chem.unep.ch/saicm/)
- Stockholm Convention on Persistent Organic Pollutants [www.pops.int/](http://www.pops.int/)
- The LEAD Group Inc. [www.lead.org.au](http://www.lead.org.au)
- "Green Lead" - oxymoron or future vision?  
[www.lead.org.au/bblp/Green\\_lead/index.htm](http://www.lead.org.au/bblp/Green_lead/index.htm)
- United Nations Environment Programme [www.unep.org/](http://www.unep.org/)
- World Business Council for Sustainable Development [www.wbcsd.org](http://www.wbcsd.org)

## GLOSSARY OF TERMS

### **Adaptive management**

A systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. The ICMM Good Practice Guidance on Mining and Biodiversity refers to adaptive management as 'do-monitor-evaluate-revise'.

### **Cleaner production**

Meaning the continuous application of an integrated preventive environmental strategy to processes, products, and services in ways that increase efficiency and reduce risks to humans and the environment. By reducing pollution and waste at the source, and striving for continuous improvement, cleaner production can bring financial as well as environmental benefits.

### **Design for the environment (or eco-design)**

An approach that examines a product's entire lifecycle and proposes changes in product design to minimise its environmental impact from its manufacturing and distribution and during its lifetime.

### **Extended producer responsibility**

The application of responsibility for managing the environmental and social impacts of a good at its end-of-life to the producer (or brand name) of the good.

### **Eco-efficiency**

Eco-efficiency is "reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's carrying capacity". (WBCSD 2000)

### **Industrial ecology**

The application of the foundation principles of ecology (dynamic equilibriums) to industrial operations, ie the conversion of waste streams (including by-products) to resource streams.

### **Life cycle**

To make such an assessment, a company needs to examine each step in the life cycle of a product, including those that are easily overlooked, such as the fate of the product after its useful life.

These steps will typically include the extracting and processing of materials; manufacturing, transportation and distribution; use, reuse, maintenance; recycling and final disposal.

### **Materials stewardship**

Overarches the stewardship approach since it applies to resources, processes and products and so covers the full life cycle.

### **Process stewardship**

Involves a program of actions focused on ensuring that processes, such as beneficiation, flocculation, crushing, gravimetric separation, and others that are used to produce ores, concentrates and other mineral products are undertaken in a socially and environmentally responsible manner.

### **Product stewardship**

This is perhaps the best known form of stewardship, is a product-centred approach to protecting human health and the environment. It aims to minimise the net environmental impact from product use, including its manufacturing; distribution; servicing; and end-of-life management; through product and product system design as well as regulatory controls and provision of appropriate management information to all who come in contact. This is a product-focused approach that attempts to build engagement throughout the value chain, including with customers.

Under a broader scheme of Product Responsibility, or Stewardship, other stakeholders (partners) who would share responsibility include consumers (responsible use and disposal of the material) and recyclers or waste managers who deal with products at end of life.

### **Resource stewardship**

Involves a program of actions to ensure that resource inputs to a process, including the minerals, water, chemicals, and energy are being used for their most efficient and appropriate use.

### **Social licence to operate**

The social licence is the recognition and acceptance of a company's contribution to the community in which it operates, moving beyond meeting basic legal requirements, towards developing and maintaining the constructive relationships with stakeholders necessary for business to be sustainable. Overall it comes from striving for relationships based on honesty and mutual respect.

### **Stewardship**

Stewardship (also known as materials stewardship) is an overarching term that encompasses product, process and resource stewardship. It describes an integrated program of actions aimed at ensuring that all materials, processes, goods and/or services that are produced, consumed and disposed of along the value-chain are done so in a socially and environmentally responsible manner.

### **Value chain**

The processes and practices in the production and use of a material or product that collectively comprise the value of the good.

### **VOCs**

Volatile organic compounds are emitted as gases from certain solids or liquids. Some VOCs have short-term and long-term health effects. Organic compounds are widely used as ingredients in household products such as paints, varnishes, wax and many cleaning, disinfecting, cosmetic and hobby products.

## APPENDIX A: LIFE CYCLE ASSESSMENT

The methodological framework for life cycle assessment contains four elements:

- goal and scope definition
- life cycle inventory
- life cycle impact assessment
- life cycle interpretation.

Under the first of these headings, the system boundaries of the product or plant unit under study are established; in this instance covering the processes involved in resource extraction and minerals processing. The life cycle inventory involves construction of a resource and waste inventory for the system being studied.

The inputs may begin with materials used in exploration drilling and subsequent excavation, take in the ore itself and substances used in its treatment or refining, and include materials used in fabrication of products. Process water would also come under this heading. Similarly, an energy budget might include inputs such as petroleum products, gas, coal or electrical power.

The life cycle impact assessment involves the exercise of judgment in the selection of impact categories and then adoption of metrics for their assessment. For example, contributions to global warming might be reported in terms of equivalent quantities of carbon dioxide-equivalent, acidification in terms of sulfur dioxide-equivalent and nitrification in terms of phosphate-equivalents.

The final stage is life cycle interpretation reviews the findings of the previous stages in regard to data and methodological uncertainties, to arrive at significant findings of which part of the system contributes most to each of the environmental impact categories studied (also called contribution analysis). This life cycle interpretation then feeds into decision-making processes on how to respond to the identified direct and indirect impacts. Such decisions will consider economic as well as an environmental dimensions and, sometimes, the two will go hand in hand, as when, by reducing electricity consumption, the company saves money and reduces greenhouse gas and other pollution associated with electricity generation at a distant location.

The development of a life cycle assessment is an inductive and iterative process, with the individual steps being identified one-by-one. It is possible that one or more steps may be overlooked or that their importance may not be fully realised as the assessment develops. Wide consultation can help to ensure that all steps are identified and their ramifications taken into account.

This can involve technical specialists in the company as well as executives, but should extend to consideration of the regulatory regime and also take into account the views of the public which may be available from an already-established community consultative committee.

Thus life cycle assessment can include elements of risk assessment as a way of identifying key points in the assessment over which there could be diverse views. Classical treatments of risk, as set out in the standard AS/NZS 4360, involve consideration of intrinsic hazard, the likelihood of exposure to the hazard and the possible consequences of exposure. In dealing with a broad constituency, however, it is necessary to take account of perceptions of risk, which will often differ from the less personal approach, set out in AS/NZS 4360. Experience suggests that community members are likely to over-estimate risk, while representatives of industry are likely to underestimate risks, especially in their own industry or sector. To ensure the acceptability of any stewardship scheme, it is important that the community view be taken into account and that such concerns are adequately covered by industrial practice.

## APPENDIX B: SPECIFIC CASES

**B1:** An example of resource stewardship is the industrial ecology systems such as the water management system operating in Central Queensland. In this system, potable water is initially used for its most valuable and appropriate use, supplying drinking water for the town of Rockhampton, before being discharged to the sewage works. However, rather than discharge the treated sewer water into the local river, the lower quality water is now diverted into an industrial use at the nearby Queensland Alumina Refinery at Gladstone, where it substitutes high quality potable water. Some of the sewage works effluent is used at Gladstone Power Station for ash conditioning, but 6.5 megalitres per day has been made available to the alumina refinery, reducing its consumption of fresh water by this amount. Thus, at these two stages of its life cycle, the water is being used for its most efficient and appropriate use. Further treatment of the industrial effluent to restore it for to higher value use is not possible at present since it is used to transport refinery waste solids. Information about the project is available at the web site [www.csrp.com.au/database/au/glad/qal\\_effluentreuse.html](http://www.csrp.com.au/database/au/glad/qal_effluentreuse.html) .

**B2:** The Product Stewardship for Oil program for recovering lubricants and oils, being run under the Commonwealth Product Stewardship (Oil) Act 2000 for the recovery and recycling of used lubricants and oils is an example of a co-regulatory scheme (van Berkel, 2006). Details and annual reports are at the web site [www.deh.gov.au/about/publications/annual-report/03-04/reports-oil-stewardship.html](http://www.deh.gov.au/about/publications/annual-report/03-04/reports-oil-stewardship.html) .

**B3:** The television and tyre sectors have approached Australian governments to develop a national 'regulatory safety net', to ensure a level playing field by requiring similar outcomes from non-participants in voluntary sector schemes. The same motive led to the development of the National Environment Protection Measure (NEPM) for Used Packaging Materials that underpins the voluntary National Packaging Covenant. The NEPM was extended in 2005 for a further five years and further information is available at the web site [www.ephc.gov.au/nepms/upm/upm\\_intro.html](http://www.ephc.gov.au/nepms/upm/upm_intro.html) .

**B4:** Other sectors have developed co-regulatory schemes, notably through the work of the World Business Council for Sustainable Development (WBCSD). The council was established to coordinate the input of global business to the Earth Summit in Rio in 1992. It fosters sustainable development and has stewardship elements in its key program areas of eco-efficiency, corporate social responsibility and accountability and transparency. The development of a co-regulatory approach does not preclude governments considering other alternatives such as full regulation, if voluntary schemes do not deliver tangible results. Information about stewardship schemes is available on the council's web site [www.wbcds.org/](http://www.wbcds.org/) .

**B5:** In Australia, the aims of eco-efficiency are for example pursued through Eco-Efficiency Agreements, which are partnerships between Australian industry associations and the Australian Government Department of the Environment and Heritage. Eco-efficiency Agreements are voluntary, three year agreements. Their content is flexible and can be tailored to the needs and requirements of different industries and business sectors. An Agreement enables industry associations to go



beyond standard practice and to work with their members to implement practical, effective strategies for change that bring both financial and environmental benefits. By mid-2005, the Department of the Environment and Heritage had signed 25 eco-efficiency Agreements with industry associations. The minerals sector was not represented directly, but a number of their customers and suppliers have done so. Also, each state and territory Chamber of Commerce and Industry (or equivalent body) has entered into an agreement with the Commonwealth. Further information is available at the web site <http://eriss.erin.gov.au/settlements/industry/corporate/eecp/agreements/index.html> .

**B6:** The Australian bauxite/alumina/aluminium industries are very much part of a globalised industry and, in addition to engagement in the Asia Pacific Partnership for Cleaner Development and Climate and Australian programs such as Greenhouse Challenge/ Challenge Plus, are involved in the global aluminium sustainability initiative "Aluminium for Future Generations". The Aluminium for Future Generations Initiative is a program of continuous improvement on the part of the aluminum industry, overseen by the International Aluminum Institute (IAI). It comprises twelve voluntary objectives, covering all key phases of aluminum's life cycle. The industry's performance towards meeting these objectives is measured annually against twenty two performance indicators. The number of voluntary objectives is increasing year by year. A copy of the latest update is available at the web site [www.world-aluminium.org/iai/publications/documents/update\\_2005.pdf](http://www.world-aluminium.org/iai/publications/documents/update_2005.pdf) .