

# ENVIRONMENTAL CATASTROPHES IN THE MINING INDUSTRY IN AUSTRALIA AND THE DEVELOPMENT OF CURRENT MANAGEMENT PRACTICES

Raghu N. Singh

Department of Civil, Mining and Environmental Engineering,  
University of Wollongong  
NSW 2522, Australia  
Phone: + 912 42213070, Fax: + 912 42213238  
e-mail: Raghu\_Singh@uow.edu.au

## ABSTRACT

*Australia is one of the leading resources countries in the world characterised by highly productive, immensely competitive and intensively mechanised mining operations. Despite these attributes, the mining industry in Australia has made its fair share of environmental mistakes and has often met with public disapproval of its environmental performance. In this paper, a brief description of a case history is given, where mining of a poly-metal pyrite ore over a 100 year period contributed \$A4.00 billions to the local economy and created the greatest environmental disaster in the history of Australian mining. The paper also describes the evolutionary development of mining legislation controlling the environmental performance of mining operations from exploration to the mine rehabilitation stage using a consultative approach. This is supplemented by a pleasing initiative taken by the mining industry to develop a Code for Environmental Management adopted by some 80% of mining companies in Australia. It is hoped that these latest legislative and voluntary developments in environmental management practice will help mitigate the effects of any major environmental incidents in the future.*

## INTRODUCTION

Australia is one of the major producers of minerals in the world and is responsible for some \$A22 billion worth of total mercantile exports. It ranks first in the world for exporting coal, iron ore, lead, diamonds, zinc concentrates and mineral sands. It is also a prominent exporter of alumina, uranium, aluminium and gold. To the public at large, mining is viewed as an essential industrial activity but incompatible with protection of the surface environment. This is due to the fact that, in many instances, past mining operations did not always consider environmental effects as part of their mining and processing operations. As a

consequence, the scars of past mining operations could be seen in many parts of the industry as environmental dereliction. However, environmental issues have assumed unprecedented prominence in Australia over the past several years and occupied a central position in the political, social and economic arena (Whitehouse, 1992, and Anon, 1994). Research in Australia and overseas has established that the mining and smelting of sulphide minerals, disposal of tailings and the management of waste water in mining operations are some of the major environmental issues (Woods, 1991; Taylor, 1998 and Harries, 1998). Various incidents indicate that erosion of tailings dumps and disposal of waste water in rivers have impaired the river

water quality several kilometres downstream from mining operations (Norris, 1986 and Craze, 1971). Therefore, mine waste water quality monitoring and treatment is becoming an increasingly important issue to local communities (Anon 1994). It is reported that "Australia has many thousands of historic abandoned mine sites of which a significant fraction are sources of pollution from oxidation of sulphidic materials" (Harries, 1998).

In this paper some environmental disasters which have occurred in the mining industry in Australia are outlined together with the current regulatory regimes to control re-occurrence of such environmental incidents. An Environment Management Code adopted by the Australian mining industry to improve its environmental performance is also described. The Code does not set the environmental standards but expects the individual mining companies to commit themselves to continual improvement by putting environmental management systems in place to achieve full compliance.

## ENVIRONMENTAL DISASTERS IN AUSTRALIA

Australia has had a fair share of environmental mishaps in the history of its mining industry, and some of the well known environmental incidents are presented in Table 1. From the analysis of this table it can be concluded that major environmental problems in the past can be attributed to:

- Mining and processing of sulphide ores.
- Acid mine drainage discharged into river systems.
- Erosion, lack of treatment and rehabilitation of tailings dams or spoil heaps.

It can also be seen that most environmental problems are not just the legacy of the past but that some of them had not been rectified even in 1998. For example, run-of-coal wash from the escarpment area near Kemira Colliery during the floods of August 1998 in Wollongong which partially buried some residential buildings.

One of the greatest sources of embarrassment to the Australian mining industry is the environmental impact at the Mt Lyell mine in Western Tasmania resulting from continuous mining and processing operations from 1893 to 1994. During this period 100 million tonnes of sulphide ore, 1 million tonnes of copper, 35 tonnes of gold and 700 tonnes of silver were produced which contributed some \$A4.0 billion to the Australian economy. During the earlier part of the operations, 11 different smelters used a pyritic smelting process utilising the heat generated by the combustion of pyrites for smelting with local timber used as a fuel. It is estimated that that during the year 1900 some 1000 woodcutters were employed to cut wood in the surrounding rain forest to fire the furnaces and to provide timber support in the mines (Blainey, 1954). At this stage 200,000 tonnes/year of sulphur dioxide were being discharged into the atmosphere. The combination of sulphur, forest fire and torrential rain scoured the hills (Montgomery and Del Grande, 1998).

In 1922, the earlier smelting process at Mt Lyell was discontinued and the ore was processed using froth flotation to produce a 26% copper concentrate, feeding to the local smelters. The tailings from the processing plant were directly discharged into the Queen river which flowed forty kilometres through Queenstown into the King River and down to the sea at Macquarie harbour. In addition, the mine discharged highly acidic mine water as a result of underground caving operations underneath an extensive open-cut, thus oxidising the sulphide ore and producing sulphuric acid. An unconsolidated waste stockpile containing approximately 50 million tonnes of sulphide waste also contributed to the acid mine drainage. As a consequence of past ignorance and environmental neglect the following environmental degradation resulted:

- The Queen river has been silted with sludge from mining up to a few metres in depth. It is estimated that 90 million tonnes of untreated tailings were discharged into the Queen river between 1922 and 1994 and this practice of tailings disposal into the river is still continuing. The Queen river is considered to be environmentally dead.
- Acid drainage from the mine and the uncompacted waste dump is 100 Litre/second. Acidic effluent from the mining lease area carries in excess of 2.5 tonnes of copper per day to the downstream catchment (Environment Australia, 1997).
- The mountains surrounding Queenstown are devoid of vegetation, trees and soil.
- Where the King river joins the harbour an unfertile delta has formed which is unlikely to disappear without any major environmental clean up.
- The copper load of the mine effluent is estimated as 2.5 tonnes / day. (Miedecke, 1996). A carpet of thick copper-containing sludge has formed in the harbour area.
- The river pollution is exacerbated by the construction of a dam by Tasmania's Hydro Electric Corporation above the mine reducing the flow of water into the King river by 80% thereby impairing its self-flushing capability.
- Marine devastation can be traced back to mining because of contaminant transport in an area of some of the highest rainfalls in Australia.

Renison closed its mining operations in December 1994 without making any attempts to remedy the environmental devastation (Montgomery and Del Grande, 1998). Its successor, Bohhannen's Copper Mines of Tasmania are attempting to extract 20 million tonnes of deeper ore in an environmentally sustainable manner. Since 1995, the Commonwealth jointly funded with the state government and CMT a project to rectify the environmental damage caused by Mt Lyell. This project is being supervised by the Supervising Scientist of the Commonwealth Government.

Mine	Period	Source of Pollution	Impact	Remedial Measures
MT LYELL MINE (Cu, Zn, Au and Ag, mining and smelting)	1896-1969	<ul style="list-style-type: none"> <li>• Tailings discharged in to river</li> <li>• Smelting of copper ore and high rain fall</li> <li>• Using wood from local forests as fuel in smelters</li> </ul>	<ul style="list-style-type: none"> <li>• River is dead, banks 1 m deep in silt and sludge</li> <li>• No surface soil and no vegetation</li> <li>• Metallic sludge in river bed and harbour with no marine life.</li> </ul>	
RUM JUNGLE (uranium and copper mine)	1954-1971	<ul style="list-style-type: none"> <li>• Five open cuts</li> <li>• Three overburden heaps</li> <li>• Tailings discharged into Finnis River</li> <li>• Copper heap leach pile</li> </ul>	<ul style="list-style-type: none"> <li>• Depletion of aquatic flora and fauna</li> <li>• Wind and rain denudation of tailings</li> <li>• Public health hazards</li> </ul>	\$18.6 millions public money to rehabilitate
CAPTAINS FLAT (Pb, Cu, Zn and Au Pyrites)	1874- 1962	<ul style="list-style-type: none"> <li>• Underground mine (acid mine drainage)</li> <li>• 2.5 Mt mine waste dumps</li> <li>• Leachate from dumps pH - 2.8</li> <li>• Tailings dam erosion - river siltation 800mm</li> </ul>	<ul style="list-style-type: none"> <li>• Erosion of dumps</li> <li>• 800 mm river siltation</li> <li>• Elevated level of Zn in River</li> <li>• Depression of fauna</li> </ul>	\$ 3 M for rehabilitate tailings dumps and diversion of surface water from U/G mine.
HARTLEY VALLEY AND CLARENCE COAL MINES IN KATOOMBA	1981- 1998 1980 - to date	<ul style="list-style-type: none"> <li>• Water discharge from Katoomba seam to Hawkesbury River system. (Water treatment under EPA licence)</li> </ul>	<ul style="list-style-type: none"> <li>• pH Mine water - 3.7 to 7.2</li> <li>• Elevated level of Mn, Zn and iron in river water</li> </ul>	Treatment of water before discharge to meet EPA licence conditions.
GOLD MINING IN VICTORIA	1800 <sup>s</sup> Dredging Open pit U/G mines	<ul style="list-style-type: none"> <li>• Crushing and grinding</li> <li>• Amalgamation process (Hg in tailings)</li> <li>• Cyanide process</li> <li>• Tailings dams and water discharge into river</li> </ul>	Wide spread mercury in lakes	
PORT PIRIE ( Lead smelting)	1876- 1976	<ul style="list-style-type: none"> <li>• Air pollution high stack from smelter</li> </ul>	<ul style="list-style-type: none"> <li>• 200,000 t unaccounted lead sediments, in soils and vegetables</li> <li>• Lead poisoning of children</li> </ul>	
KEMIRA COAL MINE (MOUNT KEIRA)	1848-1991	<ul style="list-style-type: none"> <li>• Coal spoil heaps on escarpment area</li> </ul>	<ul style="list-style-type: none"> <li>• Run off tailings in storm and burying the residential buildings in Wollongong in 1998</li> </ul>	
MOUNT ISA MINES (Pb, Zn and Cu mining and smelting)	1934-to present	<ul style="list-style-type: none"> <li>• Dispersion of smelter smoke through tall stacks</li> </ul>	<ul style="list-style-type: none"> <li>• Acid rain problems in widely dispersed area</li> <li>• Degradation of vegetation on hills.</li> </ul>	

Table 1 Historical examples of environmental impact of mining and minerals operations.

## CURRENT ENVIRONMENTAL MANAGEMENT PRACTICE IN NEW SOUTH WALES

### Environmental approach to mine planning

By its very nature, mining operations disturb the surrounding natural land, air and aquatic environments. Therefore, it is necessary to conduct mining operations with environmental safe guards in place and to rehabilitate the land surface after completion of the mining operations in order to meet the expectations of the community, government and the industry. Mining and exploration in the Australian State of New South Wales, are authorised under any of the following three principal legal authorisation procedures:

- 1) A Mining or Coal Lease issued by the Department of Mineral Resources and operated in compliance with the lease conditions.
- 2) By virtue of the private ownership of the mineral and in

accordance with the conditions of the development consent. This is implemented by the State Environmental Protection Authority.

- 3) Under a title granted under the Crown Lands Act by the Department of Conservation and Land Management.

Thus, in recent years there has been a shift in the public expectation requiring that the regulatory authorities should pay emphasis to anticipating and preventing environmental impact due to mining rather than using the earlier reactive approach (Whitehouse, 1992). The Department of Mineral Resources is responsible for promoting mining development, management and utilisation of minerals resources in New South Wales. It places emphasis on environmental factors in the planning, operational and rehabilitation phases of mining. This objective is achieved by using a combination of environmental management plans, appropriate conditions on titles, and financial guarantees of performance in accordance with Section 70 (2) (a) of the Mining Act 1992, developed in consultation and co-operation with the industry (Epps, 1991).

## Lease conditions and financial guarantees

Most mining in New South Wales is authorised by a title issued under the Mining Act 1992. The principal sections of the Act enabling the imposition of conditions are: Section 70 (1) (a) - under which a mining operation cannot be suspended without written consent of the Minister, Section 237 which protects natural resources, Section 238 which includes conditions for protecting the environment and Section 239 which deals with the rehabilitation of areas damaged by mining. The last condition is particularly important as it permits the Department of Mineral Resources, through the Minister, to vary the environmental or rehabilitation conditions in a mining title. This power of amendment illustrates that the importance placed on satisfactory environmental performance is the only way that the lease conditions may be unilaterally varied during the term of the lease, and applies to environmental matters only.

Until passing of the Mining Act 1992, the only available sanction for breaches of the lease conditions was the cancellation of the tenement. While this threat is still pertinent, implementation of such threat in reality is highly unlikely. However, the Mines Act 1992, Section 5, made it an offence to carry out mining in contradiction to the conditions of the mining lease specified in the Mining Rehabilitation and Environmental Management Plan (MREMP) issued by the Department of Mineral Resources.

## Mining rehabilitation and environmental management

The Mining Rehabilitation and Environmental Management Plan is an essential official vehicle for introducing environmental considerations into mine planning (Brook et al, 1994). It limits the adverse effects of mining, reduces environmental cost and provides an agreed procedure for rehabilitation of the mine after mining operations have ceased. In order to encourage responsible mine environmental management, the title holders are required as a condition of their title to submit to the Department of Minerals Resources a detailed MREMP for approval. This plan is reviewed annually throughout the life span of the mine. All concerned authorities are represented at a single on-site meeting to discuss the plan with the mine operator's representatives. The plan is then approved as it was submitted or in a modified form. Compliance with the approved plan is then mandatory, although there is a provision for amendment during the year if circumstances change. The annual reporting procedure is the key element to MREMP. Thus, the Environmental Rehabilitation and Environmental Management Plan provides flexibility to both mine operators and government in response to changing circumstances and increasing knowledge of the local environment. In order to assist the mine operator in the preparation of an MREMP, an extensive set of guidelines are available in the Department of Mineral Resources incorporating both short term mining operational objectives and long term rehabilitation goals for the

mine. The scope of the MREMP documentation can be varied to suit the scale of operations. The Department of Mineral Resources is responsible for overseeing the plan, for co-ordinating the input of various government authorities and ensuring that the mine operations and rehabilitation programs are being carried out in accord with the lease conditions and the MREMP. The advantages of the Mine Rehabilitation and Environmental Management Plan are as follows:

- The plan incorporates all government actions and mine compliance in a single document, thus avoiding conflicting government requirements and developing a single reporting system.
- The agreed MREMP permits rapid evaluation of controls and eliminates unnecessary duplication of efforts by various government authorities and the mine operator.
- For the Department of Mineral Resources, the MREMP ensures that environmental planning is an integral part of mine planning and not introduced piecemeal or as a matter of minor importance.
- An annual review and a single combined site inspection meeting eliminates a great deal of interference and duplication by government departments.
- An integrated mine planning and environmental management approach has resulted in cost reductions for many mining operations. Thus, the MREMP concept is a valuable instrument for assisting both government and industry in the management of the environmental impact of mining from large gold mines to small intermittently operating quarrying operations.
- Under Section 240 of the Mining Act 1992, the Minister may order the mining lease holder to carry out rehabilitation work and if the lease holder does not comply the Minister may order a contractor to carry out remedial work (Section 241). The cost of rehabilitation can be recovered from the lease holder under Section 242 of the Act.

## AUSTRALIAN MINERALS INDUSTRY CODE FOR ENVIRONMENTAL MANAGEMENT

Motivated with the need to be accountable to the public at large and in order to take a proactive role in mining environmental matters, the Australian Mineral Industry Council has developed a Code for Environmental Management. The main elements of this Code are:

- **Sustainable development** incorporating economic, environmental and social considerations into environmental management.
- **Environmentally responsible culture generate** by demonstrating management commitment, implementing management systems and providing time and resources to educate and train employees and contractors in environmental matters.

- **Promoting partnership with the community** by consulting with the public on the environmental, economic, social and cultural issues associated with a minerals project which may concern them.
- **Risk management techniques** are to be applied on a site specific basis to obtain desirable environmental outcomes. This will involve conducting a base line study, evaluating risk for alternative project concepts, mitigation of environmental impacts of the preferred project and application of a proactive approach to foreseeable environmental risks. A contingency plan should be at hand to address an environmental emergency.
- **Integrated environmental management** is a corporate priority which integrates environmental considerations in all operations from exploration, feasibility studies, mine planning, mine design, mine operation, mineral processing, decommissioning and rehabilitation.
- **Performance targets in environmental** matters should not necessarily be restricted to the minimum requirements included in the legislation and license but should be improved upon.
- **Continual improvements** in objectives in the light of changing needs and community expectations.
- **Rehabilitating and decommissioning** a site and in order to leave it in a safe and stable condition compatible with the surrounding land.
- **Reporting** the implementation of the codes and environmental performance to all stake holders including the board of directors, the government and the community. The Mining Industry Code for Environmental Management was officially inaugurated by Senator Robert Hill, Minister for the Environment and Senator Warwick Parer, Minister for Resources and Energy on 10 December 1996. To date some 41 mining companies are signatory to the code and the same code is being applied to some 250 sites across the world. The code caters for changes in the expectations of the community and government in response to changes in technology and incorporates continued improvement and periodical review. It is hoped that with the two parallel environmental management systems in place, no major environmental catastrophe will occur in the Australian mining industry in the future.

## CONCLUSIONS

The Australian mining industry does not enjoy the confidence of the public at large due to its past legacy of environmental management. In recent years much work has been carried out in environmental research, incorporating mine rehabilitation and environmental management as a condition for the granting of a mining lease and mine operators must now give a financial guarantee against environmental lapses. In addition, a voluntary

Code for Environmental Management has been adopted by the mining industry to lift industry's environmental performance. These initiatives are considered to be a good start but it may take a long time to convince the public as whole of this. Thus, in the author opinion time is not right ripe for self-regulation.

## ACKNOWLEDGMENTS

Thanks are due to Dr J. Shonhardt for his valuable help in preparation of the final manuscript of this paper.

## BIBLIOGRAPHY

- Anon, 1994. The Management and Regulation of Water in NSW. NSW Government White Paper, May 1994.
- Australian Minerals and Energy Environmental Foundation, 1999. Australian Mining Industry: Code for Environmental Management. Groundwork, Number 3, Volume 2, March 1999, p 24- 29.
- Blainey, G., 1954. The Peaks of Lyell.
- Body, P. E.; G. R. English and D. E. Mulkahy, 1988. Lead contamination in Port Pirie, South Australia. Department of Environment and Planning Report No. 10, Department of Environment and Planning, Adelaide.
- Brooks, K., K. Hollands and L. Whitfield, 1991. Mining Rehabilitation and Environmental Management Plans-A Strategy for Environmental Management and Review in New South Wales. A consultative Document, New South Wales Department of Mineral Resources, p 1-9.
- Burrow, R., 1994. Environment Assessment and Audit - Temora, A Case Study. Lecture presented at Short Course in Environment Assessment and Audits, University of New South Wales, Session 4, Topic 2, pp 1-23.
- Craze, B., 1977. Restoration of Captains Flat mining area. Journal of Soil Conservation Service New South Wales, 33, pp 98-105.
- Dhar, B. B. (editor), 1997. Training Manual on Environmental Management of Mine sites. United Nations Environmental Programme, First Indian Edition, ISBN 81-204-1196-X.
- Epps, J., 1991. The Environment Management Plan. Epps and Associate Pty Ltd., A Paper presented at a short Course on Environmental Management for the Minerals Industry, University of NSW, Kensington, 5-9 August 1991, Session 1, Lecture 3, pp 1- 7.
- ERA, 1995. Ranger research plan 1995/96. Prepared by ERA Environmental Services Pty Ltd for Energy Resources of Australia Ltd, Ranger Mine, June 1995
- Farrell, T. P. and I. C. Calder, 1988. Management of soil lead contaminant in Port Pirie. South Australia, Lead in Soil: Issues and Guidelines, Editors:, B.E. Davies and B. G. Wixon, Science Reviews Ltd., Northwood, pp 213-233.

- Harries, J., 1998. Acid Drainage - How big a problem. *Groundwork*, Number 1, Volume 2, September 1998, pp 6-7.
- Judell, T. L. and J. D. C. Anderson, 1988. Investigation into the predicability of Volumes and Characteristics of Mine waters in Coal Seams of the Sydney Basins. *Proc. International Mine Water Congress, Aus IMM, Melbourne*, pp 319 -331.
- McCredie, A., 1983. Revegetation in the arid tropics; Mount Isa Experience. *Proceedings of North Australian Mine rehabilitation Workshop, Collinsville Coal Co, Pty Ltd, Collinsville 7-11 June 1983*, pp 173-89.
- Miedecke, J., 1996. Remediation options to reduce acid drainage from historical mining operations at Mt Lyell, Western Tasmania. *Mt Lyell Remediation Research Demonstration Programme, Supervising Scientist Report 108, Supervising Scientist, Canberra*.
- Mining Act 1992, 1992. Government of NSW Publication, Government Printers.
- Montgomery, B. and M. Del Grande, 1998. Profit and Loss. *The Australian Magazine*, August 1- 2, 1998, pp 14-18.
- Norris R. H., 1986. Mine Waste Pollution of Molonglo River New South Wales and Australian Capital Territory: Effectiveness of remedial works at Captains Flat mining area. *Australian Journal of Marine and Freshwater Research*, 37, pp 147-57.
- NT Department of Mines and Energy, 1986. *The Rum Jungle rehabilitation project. Final Project Report, Northern Territory, Department of Mines and Energy, Darwin*.
- Taylor, G., 1998. Acid Drainage: Sources, Impacts and Responses. *Groundwork*, Number 1, Volume 2, September 1998, pp 4-5.
- Tiller, D., 1990. Mercury in freshwater environment- The contamination of water bodies in Victoria as a result of past mining activities. *Report SRS 90/005, Environmental Studies Branch, Environmental Protection Authority of Victoria, Melbourne*.
- Tiller, K. G. , M. P. Del Grande; L. R. Spouncer; L. Smith and B. Zarcinas, 1976. *Environmental Pollution of the Port Pirie Region 3. Report No 15, CSIRO Division of Solids, Adelaide*
- Williams et al., 1981. Carras, J. N., Milne, J.W., and P. H.Morris. The oxidation and long term transport of sulphur dioxide in a remote region. *Atmospheric Environment*, 15, pp 2255-62.
- Whitehouse, J.F., 1992. *Environmental Legislation and Mining: What Does the Future Hold?. Paper Presented at Enviro-mine Australia Conference, Sydney, March 1992*, pp 1- 11.
- Wood I. B., 1991. *The Mount Lyell Mining and Railway Company Ltd.: an Environmental Case Study. Proceedings of 16th Annual Mining Industry Council Environmental Workshop, Australian Mining Council, Canberra, 7-11 October 1991, Perth*, pp 203-220.