1 Introduction

Kelly bought a copper mine. The old company sold a gold mine (Blainey 1978).

The history of the Mount Lyell copper mine in western Tasmania, Australia, has been as enigmatic as its beginnings. Even after a century of production and exploration, the vast mineral wealth of the mine has yet to be determined. It has been the site of historical accomplishments in metallurgical, mining and railway technology, with the opening of its railways and smelters in 1896 having been described as 'one of the seven wonders of Australia' (Blainey 1978). The mine served as an economic focal point for the development of western Tasmania with towns, railways and governments all dependent on the fate of the mine. Yet the technological miracles of yesteryear have lead to environmental impacts on an almost unimaginable scale. The existing and on-going pollution associated with the historic mining practices does not meet the present expectations of society, and the development of 'new' industries on the west coast, such as ecotourism and aquaculture which depend on a 'clean' environment, are being jeopardised by the legacy of mining.

The goal of collecting technical information and designing a remediation strategy to address environmental damage resulting from historic mining practices at Mount Lyell has been the motivation behind the Mount Lyell Remediation Research and Demonstration Program (MLRRDP). The MLRRDP is a cooperative Tasmanian and Commonwealth Government program involving Environment Tasmania and the Supervising Scientist (***oss*** & ***eriss***). This report summarises the outcomes of the MLRRDP and will serve as a starting point for the Government and the present operator of the Mount Lyell mine to advance the remediation of the region.

2 An environmental history of Mount Lyell

2.1 Setting

The Mount Lyell mine is located in western Tasmania approximately 25 km inland from the Southern Ocean in rugged mountains (figure 2.1). Queenstown, the town which grew around the mine, is about 300 m above sea level in the King River catchment. The mine site straddles the divide between the mainstem of the King River and one of its tributaries, the Queen River. The rivers flow southwestward into Macquarie Harbour, a 276 km^2 enclosed bay connected to the Southern Ocean via a narrow, shallow inlet. The King River is the second largest freshwater source to the harbour, with the larger Gordon River entering the harbour in the south.

The geographic setting of the Mount Lyell mine has exacerbated the environmental problems which have occurred as a result of mining. The mine is in the heart of the 'Roaring Forties'. Because the region is characterised by very high rainfall (approx. 2800 mm/year) there has always been a need to discharge water from the mine in order to keep it dry and allow mining. The sulphidic nature of the orebody combined with the circulation of these large volumes of water have resulted in an extensive acid drainage problem.

The development and survival of the Mount Lyell mine depended on a railway link with the coast through the rugged, inaccessible mountains of western Tasmania. A railway link which generally followed the course of the Queen and King Rivers was established connecting Queenstown with Strahan, a town on the northern end of Macquarie Harbour. Strahan and Teepokana, a port on the lower King River, became important shipping centres for the export of copper and import of mining supplies.

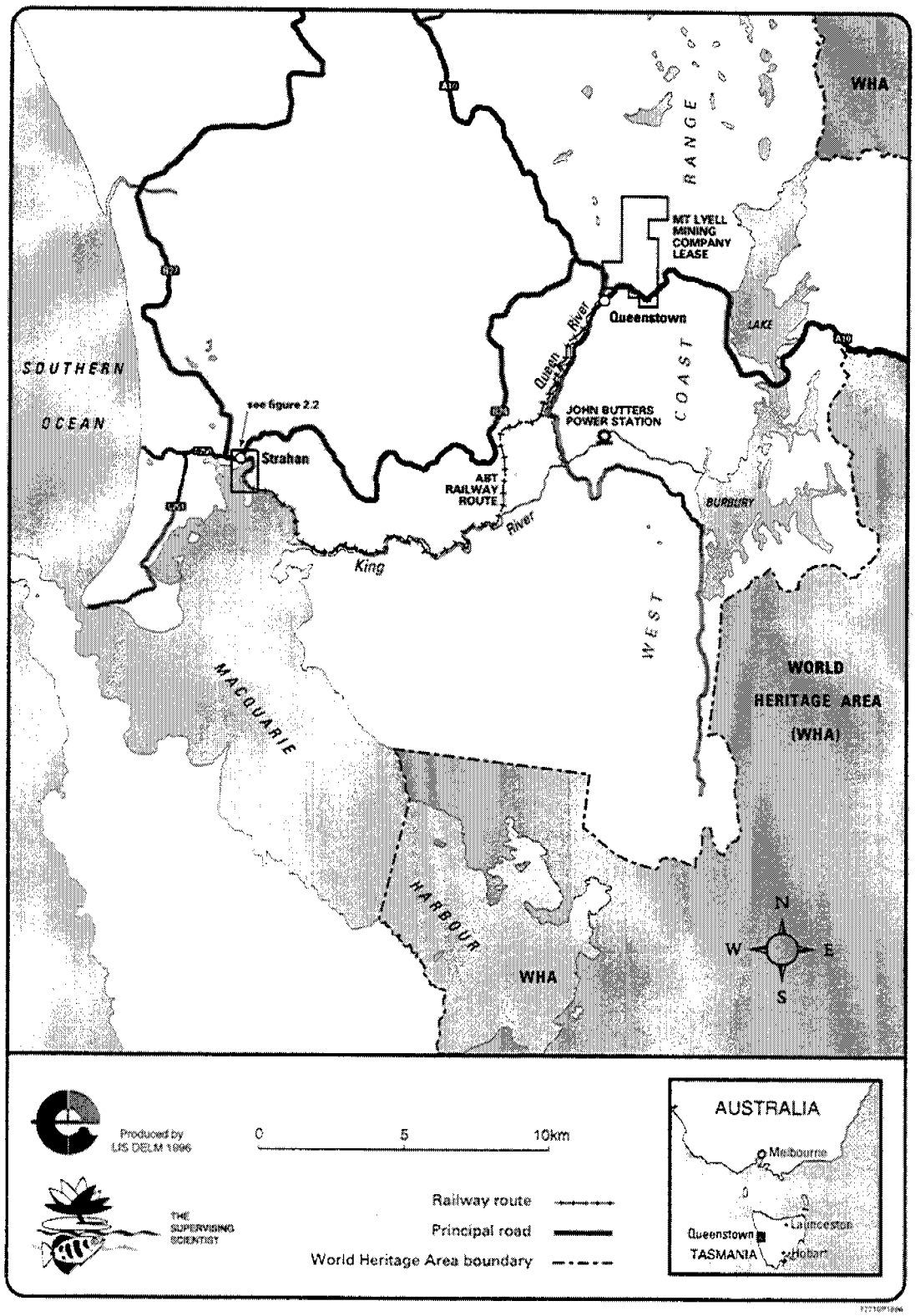

Figure 2.1 Regional map

Though no mining occurred near Strahan, historically its economic survival was dependent on the continued success of the Mount Lyell mine. Since the closure of the railway, however, Strahan has become an ecotourism and aquaculture centre, activities which are directly impacted by the past and present operation of the Mount Lyell copper mine.

2.2 The Mount Lyell copper mine

2.2.1 The Mount Lyell Mining and Railway Company

The Mount Lyell Mining and Railway Company commenced operations in 1893 and was a publicly listed company until 1981 when it merged with three other companies forming Renison Goldfields Consolidated. The mine continued to be operated by RGC until December 1994, when operations ceased in accordance with the requirements set forth in *The Mount Lyell Mining and Railway Company Limited (Continuation of Operations) Act 1992*. During the development and much of the operation of the mine, environmental controls were non-existent, and environmental management was not a concern of the operator. In Tasmania, The *Environment Protection Act 1973* established emission limits for industrial discharges into fresh waters, but Mount Lyell was issued with a Ministerial Exemption in 1974 which allowed the company to not comply with these limits. This arrangement continued throughout the life of The Mount Lyell Mining and Railway Company's operation of the mine.

2.2.2 Copper Mines of Tasmania

In 1994, Copper Mines of Tasmania, a wholly owned subsidiary of Gold Mines of Australia, took over the main mining lease at Mount Lyell, and, in 1995 recommenced the mining and processing of ore in accordance with the *Copper Mines of Tasmania Pty. Ltd. Agreement Act 1994*. CMT has constructed a tailings dam and is required to operate in accordance with an environmental management plan based on best practice environmental management achievable in the circumstances. CMT is not associated with any previous operators of the mine, and legally is not liable for the environmental damage caused by, or resulting from previous operations.

2.3 Historic mining discharges

During the tenure of The Mount Lyell Mining and Railway Company, mining on the Mount Lyell lease site involved the discharge of three types of wastes into the Queen River: large volumes of acid drainage; mill tailings resulting from flotation processing; and slag from smelting operations. All three wastes were discharged into the Queen River where they were transported as river sediment or in solution, to become distributed along about 50 km of the Queen and King Rivers, and into Macquarie Harbour. Additionally, during smelting operations considerable quantities of sulphur dioxide were emitted into the atmosphere.

2.3.1 Acid drainage

The abundance of sulphidic minerals in the Mount Lyell orebodies and surrounding host rock has resulted in the extensive production of 'acid drainage'—the term used to describe the acidic water resulting from the oxidation of sulphidic minerals when exposed to air and water. This reaction produces acid which in turn has the capability of liberating heavy metals from rock. Acid drainage is a major environmental issue worldwide, especially in high rainfall areas, and is an important aspect of the environmental management of mines operating in sulphide-bearing regions. But during the development of the Mount Lyell copper mine and for most of its long history, there was little awareness of the issue as an environmental problem, although the corrosion of railway lines and ground support systems

had been recognised as a dangerous and expensive problem in the Mount Lyell workings (Wood 1991).

There are two major sources of acid drainage on the lease site: the underground workings and the waste rock dumps. The workings were constructed without regard for minimising water ingress, and the underground open stoping method of mining used in the underground operation results in the percolation of surface and ground water through greater than 500 vertical metres of broken sulphide-bearing rock. As a consequence, millions of litres of acidic water either drain naturally from the workings or are continually pumped from the mine each year in order to permit underground operations. The waters are highly acidic and contain high concentrations of the metals copper, aluminium, iron, manganese and zinc.

Waste rock dumps on the lease site have been poorly constructed, allowing air and water to circulate freely. The waste rock associated with the West Lyell Open Cut contributes significantly to the production of acid drainage because of the high concentrations of pyritic rock and relatively high concentrations of copper (Wood 1991).

Since the occupation of the lease site in 1994 by CMT and the initiation of tailings deposition into a new dam, some of the remnant alkalinity in the tailings and process water is being utilised to neutralise a portion of the acid drainage pumped from the Conveyor Tunnel (the main route by which acid water pumped from the mine flows to the surface). Presently, about 15% of Conveyor Tunnel derived acid drainage is pumped to the tailings pond and neutralised in this manner.

2.3.2 Deforestation and acid drainage

Early in the development of Mount Lyell, forests were removed from the lease area and surrounding hills by bushfires, for the construction of the township and mining and railway infrastructure, to fuel steam-driven machinery, furnaces, and home fires, and to assist access for further mineral exploration. In 1896 Mount Lyell became the world's first mine to commercially implement pyritic smelting—a process which harnesses the sulphur and iron in the ore as a fuel source. With this innovation, which was used until smelting ceased in 1969, came a yearly discharge to the atmosphere of approximately 200 000 tonnes of sulphur dioxide (Wood, 1991). The combination of deforestation, very high annual precipitation, ground surface instability, poor nutrient levels and sulphur dioxide fumes resulted in rapid and complete erosion of soils from the steep slopes, and prevented the establishment of new growth. The loss of soils also increased the exposure of sulphide-bearing bedrock to oxygen and water, which increased the generation of acid drainage on the hill slopes. This expanded the problem of acid drainage to not only those rivers directly utilised by the mine for water disposal, but also neighbouring waterways.

2.3.3 Mill tailings and smelter slag

In addition to discharging acid drainage to the Queen River, The Mount Lyell Mining and Railway Company also discharged mill tailings and process water directly into the Queen River once preconcentration of ore using flotation technology was introduced in 1922 (Wood 1991). Between 1922 and 1994, more than 90 million tonnes of tailings have been discharged to the river system (Wood 1991, Locher 1995). The sulphide-bearing tailings have been deposited along the banks and in the beds of the Queen and King Rivers. Where the King River enters Macquarie Harbour, a large delta of mining wastes has formed. Several million tonnes of slag—a waste product from the smelting operation—were also discharged into the river, between 1929 and 1970, much of which is present deep in the sediments of the King River bed (Locher 1995).

2.4 Other catchment activities

While the Mount Lyell mine provided the 'soul' of Queenstown's and Strahan's economies for many decades, other development in the catchment has also occurred. The abundant rainfall in the King River catchment was harnessed by the Hydro-Electric Commission of Tasmania with the damming of the river and development of the King River Power Development scheme. The power scheme consists of Lake Burbury and the John Butters Power Station, which is situated a few hundred metres above the confluence of the Queen and the King (figure 2.1). The development of the King River power scheme has affected the Mount Lyell mine in two ways. Firstly, the desire to develop Lake Burbury into a recreational trout fishery raised concerns about the discharge of metal-rich acid drainage into the lake via the Linda and Comstock Creeks. This resulted in the HEC completing diversion works which minimise the amount of water entering the lake by redirecting it into the Queen River. Secondly, the running of the power station has significantly altered the natural flow of the lower King River which has altered the amount of dilution the King River provides for the metal-rich Queen River. Additionally, the reduction of large flood events in the King catchment has reduced the reworking of tailings banks which were deposited under the 'old' flow regime.

Other major developments in the catchment have been the growth of tourism and aquaculture. Both of these activities are generally centred in Strahan and have developed since the closure of the railway linking Mount Lyell with Macquarie Harbour. Strahan is the embarkation point for Tasmania's most frequented tourist attraction, the Gordon River Cruise, which carries passengers through Tasmania's World Heritage Area. Aquaculture includes the production of Atlantic salmon and ocean trout in Macquarie Harbour. Tourism and aquaculture presently contribute more than $28 million per year to the Tasmanian economy, and as both of these activities depend on a 'clean' and 'healthy' Macquarie Harbour, there are serious concerns about the impact the operation of the Mount Lyell mine has had, and is continuing to have, on the harbour. The presence of mining wastes in the nearby King River and delta and the continuous discharge of metal-rich acid drainage has limited the development of marine farming in the region, and serves as a stark contrast to the 'clean green' image the tourist industry is promoting. Not surprisingly, there has been considerable public pressure from the residents of Strahan to eliminate the problem and clean up the mining residues.

2.5 Closure of The Mount Lyell Mining and Railway Company

In December 1994, The Mount Lyell Mining and Railway Company ceased operations on the Mount Lyell lease site in accordance with legislative closure requirements. Tailings and process water ceased entering the Queen River, but the State Government of Tasmania opted to continue pumping and discharging acid drainage from the underground workings, in order to prevent the infrastructure from flooding, with the aim of attracting a new operator to the lease site to mine. Acid drainage derived from the waste rock dumps was unchanged by mine closure.

At the time of closure, the Tasmanian Department of Environment and Land Management (DELM) was aware of the environmental impact the mine had had on the river and the environment because of environmental studies which had been completed earlier by DELM, The Mount Lyell Mining and Railway Company, and through a co-operative Tasmanian project, the Macquarie Harbour – King River Study, which had been initiated in 1993. The available information suggested that in addition to large-scale environmental damage due to a

century of mining, the cessation of tailings disposal would actually result in an *increase* in the dissolved metal concentrations present in the Queen and King Rivers and ultimately Macquarie Harbour. This was because the alkaline tailings and associated process water discharged by the mine neutralised some of the acidity in the acid drainage, and, once coated with iron-hydroxides, provided adsorption sites for a large proportion of the metals leaving the lease site. This considerably reduced the dissolved metal concentrations present in the rivers and harbour. An intensive monitoring program conducted by DELM confirmed that dissolved metal concentrations increased dramatically in both the river and the harbour once the mine closed.

3 Economic and social benefits of cleaning up the lease site, rivers and harbour

The remediation of the damage resulting from past mining practices would not only be important in reducing on-going impacts on the environment, but would also have a wide range of social and economic benefits. Remediating the lease site would enhance Tasmania's 'clean green' image and send a message to the local, national and international mining and environmental communities that Tasmania is serious about addressing the environmental impacts of mining. Although most mining sites in Tasmania presently comply with strict environmental standards and implement 'best-practice' techniques, the notoriety and public exposure that the Mount Lyell pollution has received over the years has cast a shadow over the Tasmanian mining industry as a whole. A real improvement in the Mount Lyell situation would reflect favourably on both the mining industry and the Tasmanian Government.

Socially and economically, a culturally sensitive clean-up of the lease site would allow the Queenstown community to continue to promote a local tourism industry based on the preservation of the bare hills (resulting from sulphur dioxide emissions during smelting) and associated mining history with no impact on the downstream environment. A cessation of pollutant discharge from Mount Lyell would also enhance the social acceptability of continued mining on the lease site in the broader Tasmanian community. This could be significant for the approval of future mining operations, such as the resumption of surface mining in a 'super-pit', as currently being investigated by CMT.

Further downstream, improvements in the aquatic ecosystem ranging from a visual enhancement of river banks through revegetation, to major improvements in water quality would allow Strahan to promote and expand ecotourism, which is presently a multi-million dollar a year industry. Visitor survey information from Tourism Tasmania indicates that presently 25% of all visitors to Tasmania visit Strahan and contribute more than $18 million a year to the economy. The ecotourism focus of these visitors is evident in the survey results which indicate the major attraction in Tasmania is a visit to the Franklin–Gordon Wild Rivers National Park and the Gordon River cruise. Interestingly, in the group surveyed, a greater percentage of visitors to Strahan go bushwalking during their stay in the State (56%), than visit a casino (34%). The present length of stay in Strahan is only 1.6 nights; with such high interest in outdoor activities by the visitors, there is clearly room to expand ecotourism activities in the Strahan region.

The proximity of the King River greatly enhances the possibility of developing tourist activities which don't require one or more full days, unlike the Gordon River cruise or rafting the Franklin River. Because the forests lining the King River have not been severely impacted, restoring the health of the river would allow the development of ecotourism in the river catchment rather than the grim tourist attraction it presently is, and would complement