3 A century of mining

Mining and processing operations had a considerable impact on the local and regional environment. This section briefly outlines the historical mining and processing operations and presents an overview of the environmental impacts.

3.1 Mining

The Mount Lyell region was the site of copper mining and processing on a continuous basis for 102 years from early 1893 to late 1994. Table 3.1 presents a summary of principal operations since 1896. The locations are shown in figure 3.1. The Mount Lyell Mining and Railway Company Limited (MLMRCL), a wholly owned subsidiary of Renison Goldfields Consolidated Limited, ceased operations on 15 December 1994. Mining recommenced in early 1995 when the Tasmanian Government awarded the Mount Lyell leases to a new operator, Copper Mines of Tasmania Pty Ltd (CMT), a wholly owned subsidiary of Gold Mines of Australia. CMT subsequently commenced re-development of the remaining ore resource. Processing ore recommenced in November 1995, with the objective of progressively increasing production to 3.5 million tonnes per annum. The results of pre-development exploration estimate the remaining resource to 1.3 million tonnes of copper and 1 million ounces of gold. Further exploration of the lease site is likely to increase the reserve of remaining resources.

In the early 1900s there were more than 40 companies operating in the Mount Lyell mining field. The mining operations were both surface and underground, resulting in six large open pits and over 100 adits. Support infrastructure included the townships of Queenstown, Linda, Gormanston, Crotty and Darwin, railways to Teepookana, Strahan and Kelly Basin on Macquarie Harbour, and smelting operations at Mount Lyell and Crotty.

In 1903, The Mount Lyell Mining and Railway Company Limited became the sole mining company in the region through the acquisition of its major rival, The North Mount Lyell Company and its associated assets (Crotty smelters, rail system to Kelly Basin and the Port of Pillinger). These facilities were subsequently closed in favour of the Mount Lyell smelters and the Abt railway to Teepookana and Strahan.

In recent years mining has been focused on the Prince Lyell orebody. Initially mined in the West Lyell open-cut, this near vertical ore body has been mined since 1978 below the open-cut using sub-level open stoping, with pillar extraction under cave mining method (figure 3.2). The ore was funnelled down ore passes to lower levels for road haulage to the crusher station situated on mining level 18. Primary crushed ore was transported to the surface via the Prince Lyell Shaft. An overland conveyor transported ore from the shaft to the mill for concentrating.

The Mount Lyell Mining and Railway Company Limited ceased its mining operation at the sixty series stoping level in the Prince Lyell Mine 300 m below sea level. In June 1995, Copper Mines of Tasmania committed to developing the remaining resource, with an estimated ten year mine life at a processing rate of 3.5 million tonnes per annum and a head grade of 1.45% copper and 0.5 g/t gold.

Open stoping of the Prince Lyell ore body promoted the percolation of rainfall falling within the catchment of the West Lyell open-cut, down through the caved material and broken ore to lower levels of the underground operation.

Table 3.1 The period of operation of the principal mines in the Mount Lyell mining region (estimates to 1991 from Flitcroft & McKeown (1992) updated to 1994 by Snowden (1994))

Mine	Period of operation	Mining type	Production				
			Ore (10^6 t)	Waste (10^6 t)	Copper (%)	Gold (g/t)	Silver (g/t)
Mount Lyell (Iron Blow) and South Lyell	1896–1929	open-cut	5.6	4.5	1.29	1.99	61.22
North Lyell	1896–1972	open-cut and underground	4.7	N/A	5.28	0.40	34.29
Royal Tharsis	1902–1905 1930–1937 1940–1959 1964–1966 1968 1972–1974 1976 1981 1985–1994	underground	2.0	none	1.56	0.49	2.77
Lyell Comstock	1913–1921 1929–1959	open-cut and underground	1.3	N/A	2.38	0.67	5.23
Crown Lyell & Twelve West	1931–1942 1953–1954 1959–1978 1980–1985	open-cut and underground	4.0	N/A	1.62	0.37	6.67
West Lyell open-cut	1934–1972	open-cut (largest above ground operation in the area)	58.3	47	0.72	0.25	1.66
Razorback	1964–1969		0.2	N/A	1.10	0.24	1.48
Cape Horn	1969–1987	open-cut	4.1	N/A	1.43	0.42	3.30
Prince Lyell	1969–1994	underground (continuation of the West Lyell open-cut operation)	31.0	none	1.29	0.40	2.91
Lyell Tharsis	1970–1977	open-cut and underground	0.7	N/A	0.94	0.27	4.85

Waste rock was generally placed around the perimeter of the open-cut mines and is present within most sub-catchments (see figure 3.3). These dumps contribute acidic drainage products, primarily heavy metals and sulphate, to the effluent water. The 47 million tonnes of waste surrounding the West Lyell open-cut is estimated to contain 0.17% copper, giving around 80 000 tonnes of copper metal resource (Gunn Metallurgy 1993).

The waste material from the West Lyell open-cut contains approximately 10% pyrite. The most significant metal contaminants are copper and iron with less significant quantities of aluminium, magnesium and manganese. Preliminary modelling has indicated that oxidation of the waste material is occurring throughout the dumps (ANSTO 1994a, 1994b). There appears to be no factor limiting the oxidation process, which continues at the maximum possible rate. ANSTO estimated that acid generation will continue for more than 600 years. Measurements have shown that approximately 130 tonnes of copper and 1300 tonnes of sulphate per year leach from a single 25 ha waste rock dump below the West Lyell open-cut. These loads

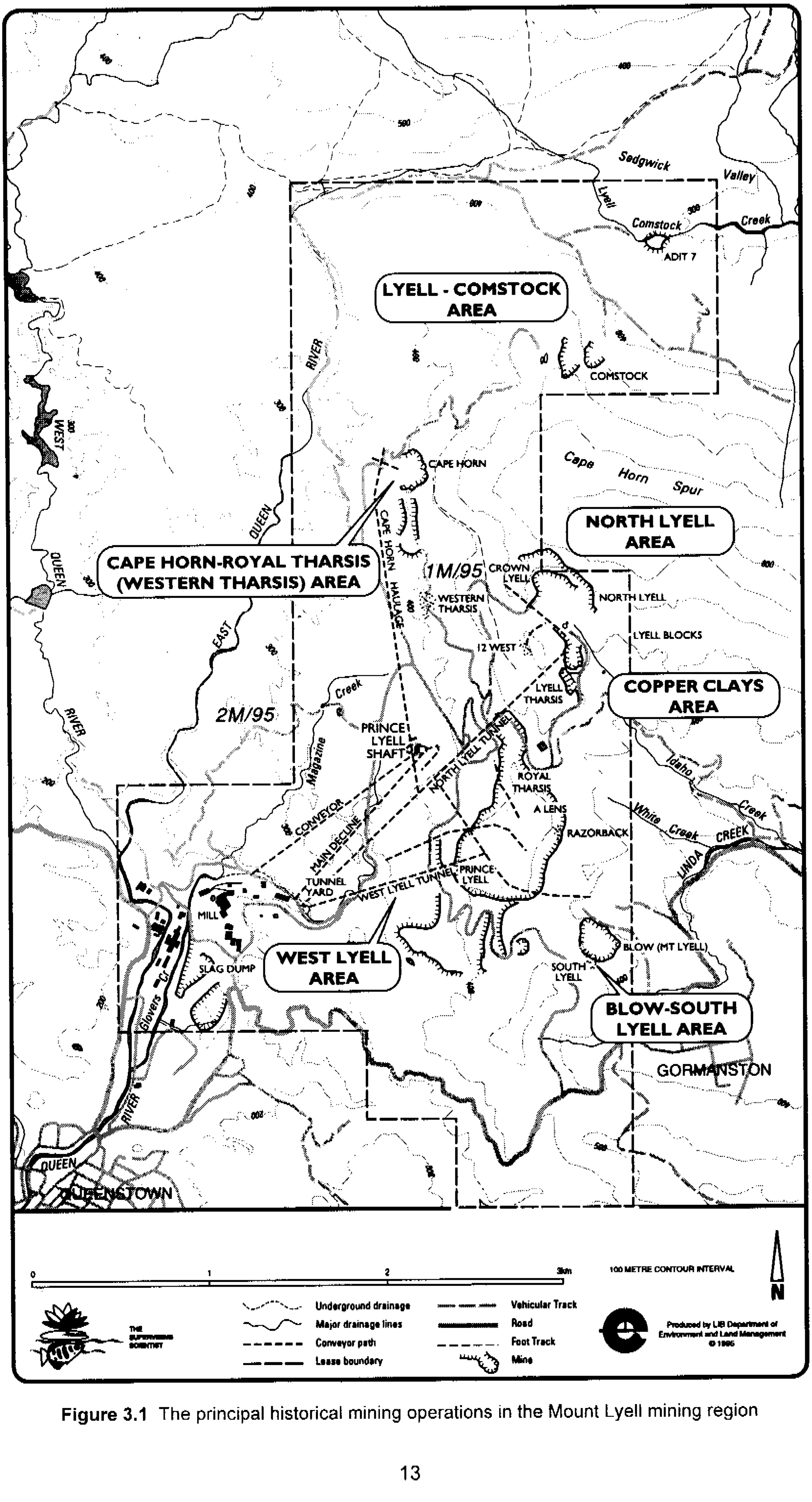

Figure 3.1 The principal historical mining operations in the Mount Lyell mining region

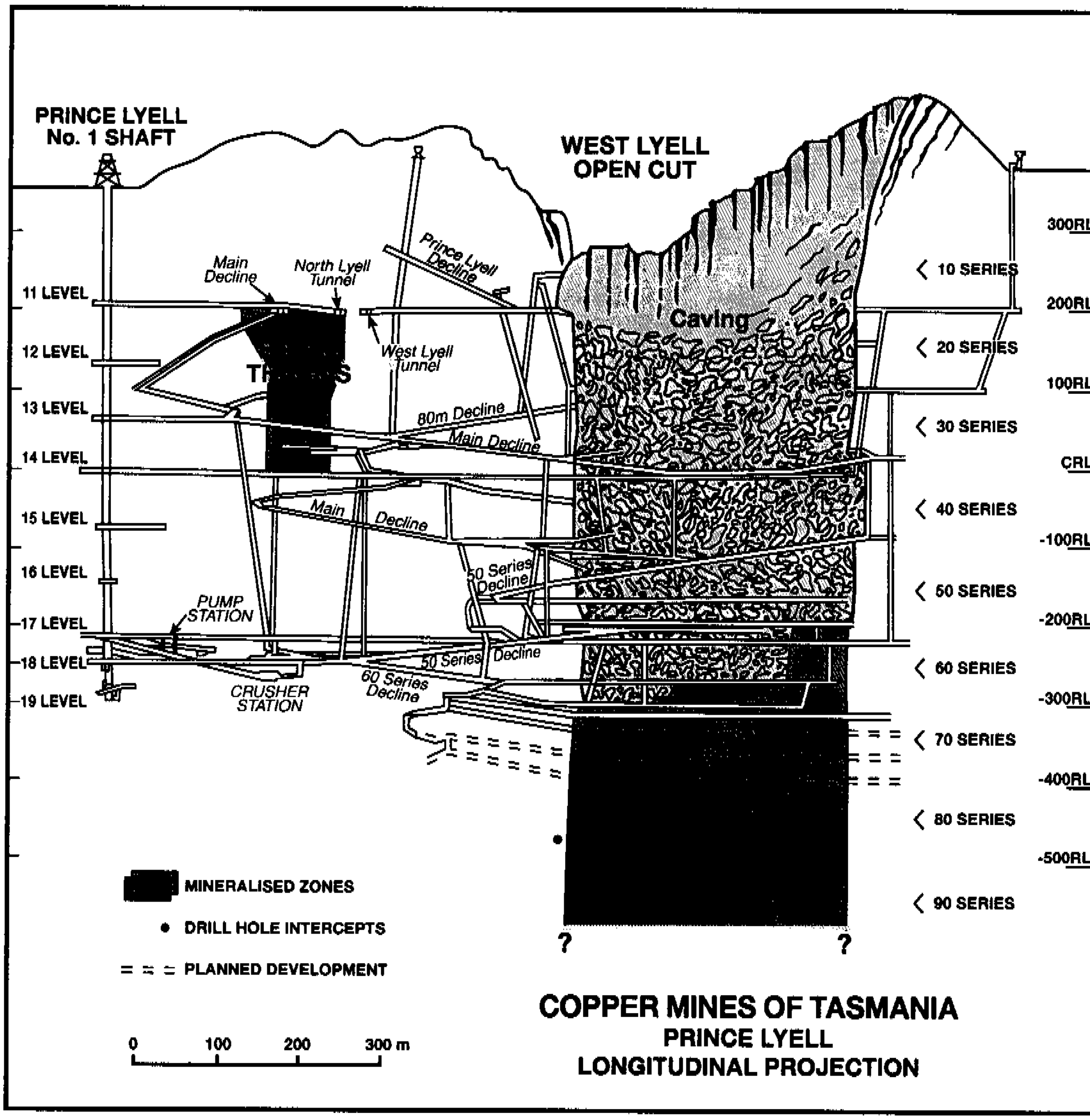

Figure 3.2 Longitudinal schematic of mining areas showing sub-level open stoping with pillar extraction under cave mining methods (after Atkinson 1982)

are expected to continue for around 20 years, after which they will gradually decrease to around 10% for an estimated 600 years. There are in excess of ten individual rock dumps over the lease area covering around 50 ha and containing approximately 53 million tonnes of rock material (EGI 1993).

3.2 Processing

In the early years of mining, appropriate technology for concentrating the copper minerals was unavailable, leading to the mining of high grade ore that could be shipped to Europe for direct smelting. Pyritic smelting, through the combustion of the iron pyrite contained within the ore, was developed and successfully implemented for the first time by the American metallurgist Robert Sticht with the commissioning of the first Queenstown furnace in 1896. Wood (1991) estimated that 200 000 tonnes of sulphur dioxide was discharged to the atmosphere annually during this phase of processing. An estimated six million tonnes of black siliceous slag was produced and stockpiled on site or discharged with tailings into the river system.

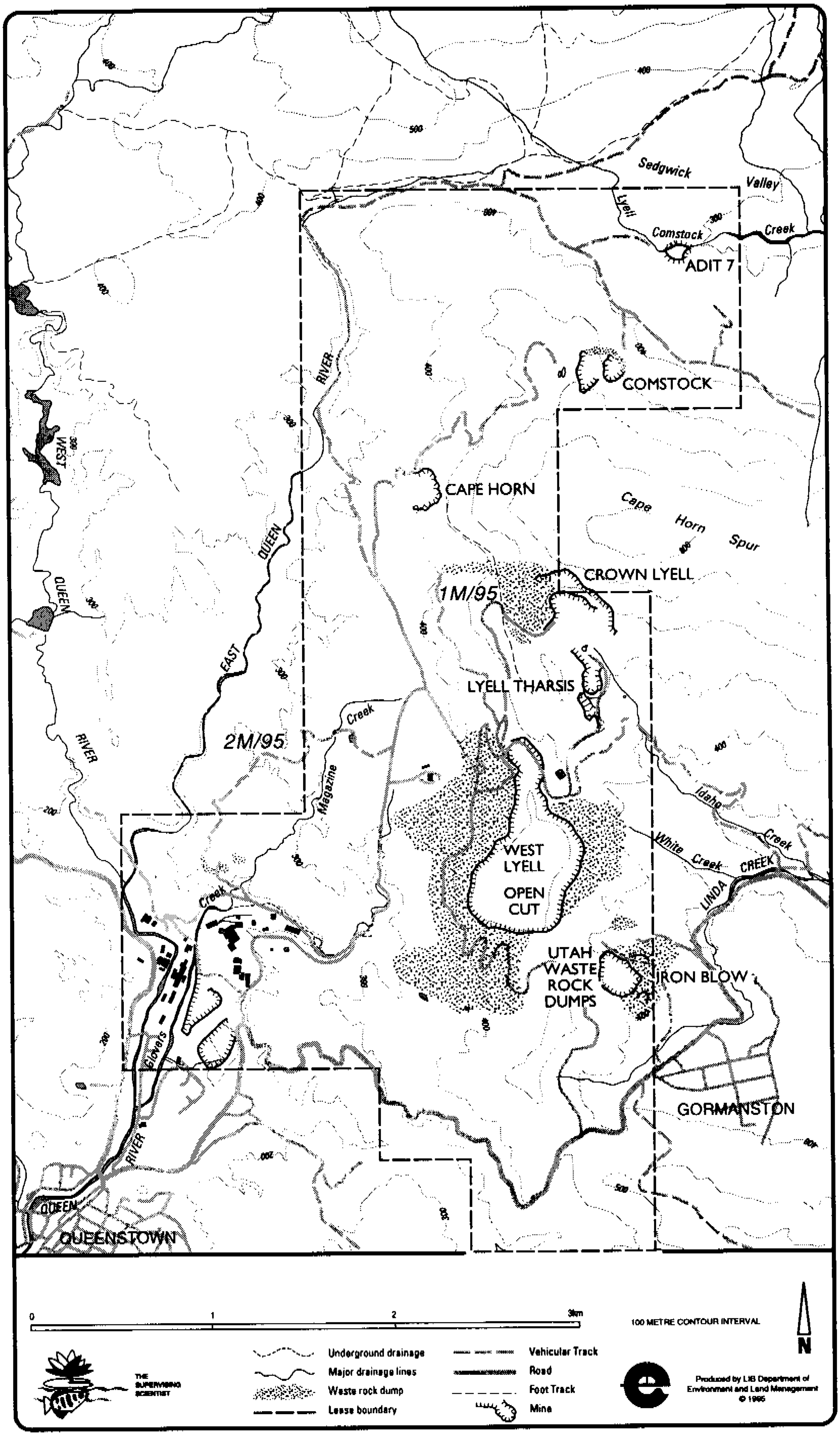

Figure 3.3 Location of waste rock dumps on the Mount Lyell Mining lease site

As pyrite grades in the host ore began to decline, alternative fuels were required to supplement the pyritic process and timber and coal replaced pyrite in 1904. Preconcentration of copper became necessary to maintain the viability of on-site smelting as the higher grade ore deposits were depleted. This was achieved through the introduction of flotation technology in 1922. Smelting operations at Mount Lyell ceased in 1969, after which concentrates of copper and pyrite were transported by rail to Strahan and later to Burnie (north coast of Tasmania) from where they were shipped to Japan for smelting. The ore processing methods are summarised in table 3.2 and tailings production is summarised in table 3.3.

Table 3.2 Ore process methods at Mount Lyell over the life of operations

Process	Period of application	Process	Period of application
Direct smelting	1893–1895	sintering plant to roast sulphur from the copper concentrate to fuel the smelters	1916–1934
Pyritic method	1896–1903	pre-concentration of ore via flotation followed by sintering before smelting	1922–1934
Semi-pyritic incorporating coal as the main fuel source	1904–1916	copper concentrate charged into the furnace in the raw state	1934–1969

Table 3.3 Tailings production rates (MLMRCL 1990)

Period	Tailings production rates (t/yr)
1922	commenced discharge to Queen River at 100 000
1928–1935	increased from 100 000 to 500 000
1935	increased from 500 000 to 1 500 000
1935–1980	fluctuated between 1 500 000 and 2 000 000
1980–1994	steady at 1 500 000
Total	approximately 97 000 000

The absence of other downstream water users, combined with difficult topography and high rainfall, resulted in tailings being discharged into Haulage Creek from where they were transported down the Queen and King Rivers to Macquarie Harbour. Co-disposal of slag to the river system also commenced, as the tailings were able to mobilise the slag which had previously been disposed of on site. Figure 3.4 shows the history of tailings and slag discharge to the Queen River. The slag dump is located adjacent to Haulage Creek and contains around seven million tonnes of material grading 0.4% copper. The tailings were discharged with a median solids content exceeding 300 000 mg/L and a pH around 9.5. This high pH acted to buffer the acidic mine water, surface waters discharging from the remainder of the site, and the acidic leachate generated from tailings beaches in the riverine systems. The tailings also provided a large surface area for the adsorption of metals leaching from the site. Approximately 100 million tonnes of tailings were disposed of to the riverine environment in this manner. The new mining operator, CMT, constructed a tailings dam located in the Princess Creek catchment with sufficient capacity to contain all the tailings generated from a processing through-put of 3.5 million tonnes per year for 60 years.

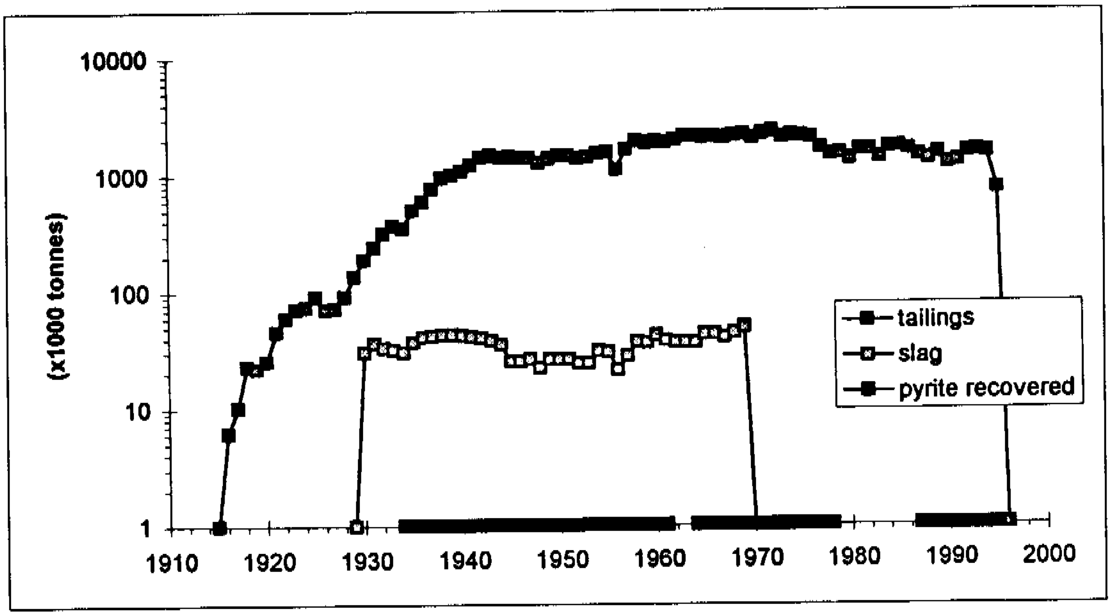

Figure 3.4 History of tailings and slag discharge to the Queen River (after Locher 1995) (reproduced with permission of the CRC for Catchment Hydrology)

The specific gravity of the tailings was measured by Locher (1995) and found to be approximately 2.9. A chemical analysis of tailings material derived from the Prince Lyell load is given in table 3.4 (MLMRCL 1990). Note that pyrite was removed from the tailings for varying lengths of time during the mining operation, depending on market demand. The recovery rate of pyrite was about 50% at peak efficiency, thereby reducing the iron and sulphur content percentage presented in table 3.4 by half.

Table 3.4 Chemical analyses of Mount Lyell tailings (when pyrite was not being removed from the ore)

Analyte	Percentage	Analyte	Percentage
SiO_2	58	S	6.0
Al_2O_3	10	CaO	0.6
Fe	11	others	14.4

The median tailings particle size determined by the MLMRCL (1990) using the hydrometer method was 26 microns which is over double that determined from a sample collected in 1993 by Locher (1995) using a Malvern Laser Scatterer. Generally, as milling technologies improved the particle size of the tailings decreased – from a median size of around 70 microns in 1916–1944 to 30 microns in 1980–1995. Slag was discharged to the river system at a reasonably consistent median particle size of around 1.6 mm (Locher 1995). Slag disposal ceased in 1969 with the cessation of smelting at the site.

3.3 Water management

Water management is a critical component for mine operation as well as for environmental protection, water being the primary medium for the transport of pollutants and a necessary component in acid generation. The median tailings discharge rate was about 200 L/s with the water for processing being sourced from the three dams on the West Queen River. In dry periods the West Queen River supply was supplemented through controlled discharge from

Lake Margaret. Water used within the mine was pumped from the East Queen River at 30 to 40 L/s into two mine head tanks above the Prince Lyell Shaft. Additional storage capacity was provided by the Utah Tanks which stored overflow from the Prince Lyell head tanks. From the head tanks water was directed underground for use throughout the mine for production purposes (MLMRCL 1994b). Mine water is also derived from precipitation falling in the West Lyell open-cut and percolating down into the underground workings. Mine de-watering pump discharge from the Conveyor Tunnel shows a relationship with rainfall with an approximate 24 hour delay.

Mine dewatering was, and will continue to be, an essential component of the mining operation allowing access to ore at depth and is a significant component of the overall water and solute balance for the site. Rainfall drains through fractures in the country rock and the mine workings where contact with pyritic material (at around ten percent sulphide) produces water with an acidity ranging between pH 2.5 and pH 3.5 and median concentrations of copper of 150 mg/L. The intensity of vehicular traffic within the mine, blasting and cave collapse, and high flows of water, result in a high solids content with particle sizes ranging from colloidal to around 6 mm. Water within the mine drains to mining level 18 (RL–246.5) from where it is transferred to settlers to remove the suspended solids through the addition of anionic flocculants at approximately 1 kg of flocculant per 1000 m^3 of mine water. Settled 'mud' is evacuated via a displacement system using water pressure from the Prince Lyell head tanks to push settled mud to RL200 and out of the Conveyor Tunnel. During MLMRCL operations mud was displaced up to eight times per day. Clear water overflows the settlers into a 4 million litre storage pond from where it is pumped via a rising main to the Conveyor Tunnel and discharged into Haulage Creek.

Historical average discharge data are considered poor, with estimates derived from pump hours. The pumps have variable performance with a theoretical maximum of 120 L/s and recorded flows to 65 L/s. Reported mean pump rates vary from 50 L/s (GH&D 1994) to 85L/s (MLMRCL 1994b). The current system comprises four pumps each with a design capacity of 120 L/s. Projections of solute loads to the Queen River are critically dependent on good flow estimates. Recently measured flow data by CMT suggest that the previous estimates were significant underestimates, with a more appropriate average annual discharge rate approaching 90 L/s and flows following heavy rainfall approaching 240 L/s. Typical discharge rates in response to rainfall for the North Lyell tunnel are shown in figure 3.5.

Mud collected within the settlers during active mining was displaced at a maximum rate of 20 L/s into the Conveyor Tunnel from where it flowed with the mine dewatering water into Haulage Creek. The solid component of the mud is estimated to be generated at an average rate of 130 t/d (CMT 1995). After the MLMRCL ceased its operations mud displacement occurred on average two to three times per day.

The mud contains considerable quantities of copper and other heavy metals, sufficient for CMT to propose processing the mud as a resource. The historical monitoring program undertaken by MLMRCL to estimate both concentrations and loads leaving the Conveyor Tunnel comprised a monthly grab sample and an estimation of flow. Due to the variability in heavy metal concentrations, depending if mud was being displaced or not, grab sampling and an estimation of flow would be unlikely to provide sufficient information to truly estimate load or concentration over time. The Conveyor Tunnel discharge represents the single greatest point source of pollution discharging from the lease site comprising in excess of 60% of the mass discharge of copper from the site. The variability of concentrations over time are addressed more fully below.

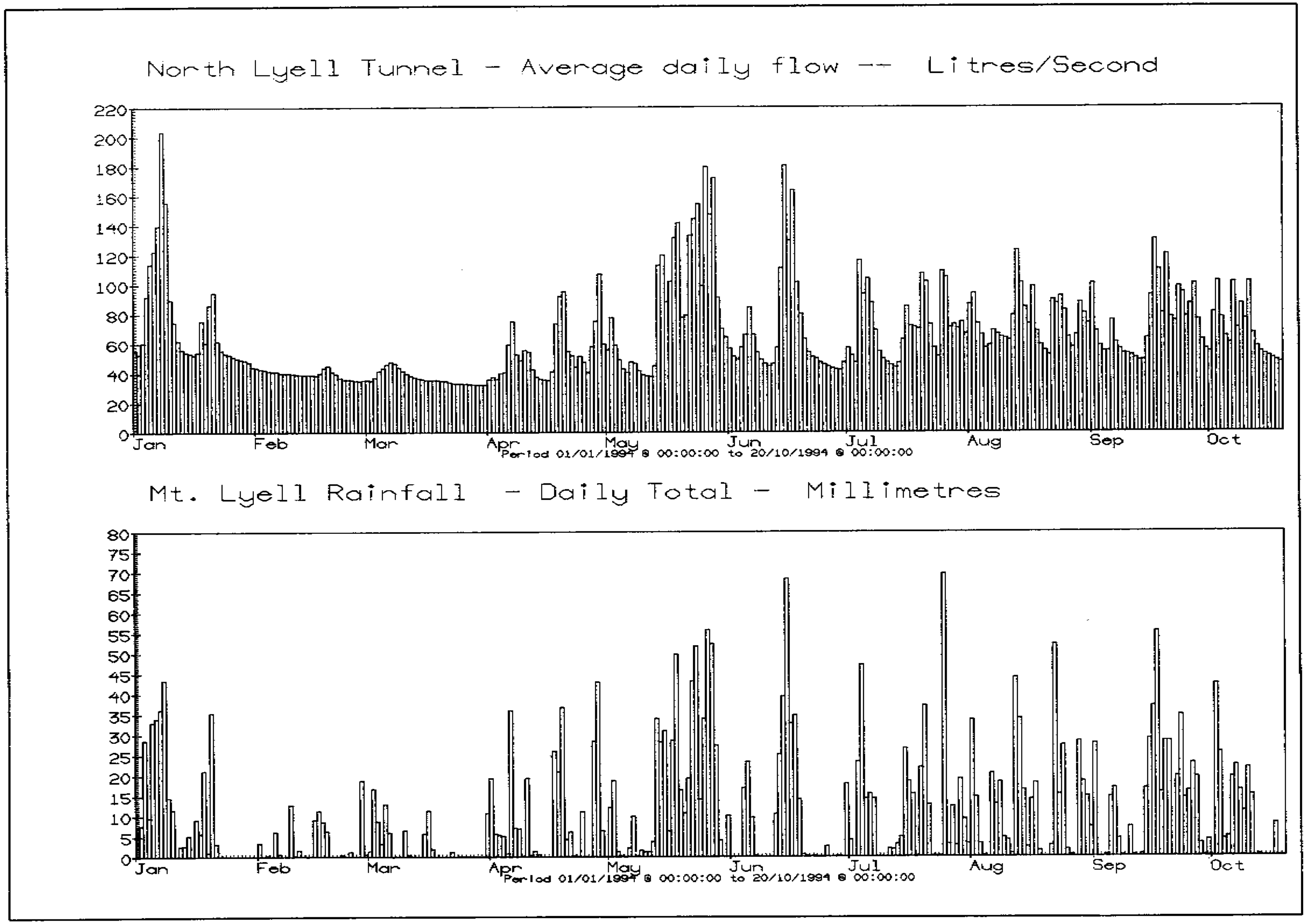

Figure 3.5 Site rainfall and discharge rate from the North Lyell Tunnel (HEC supplied data)