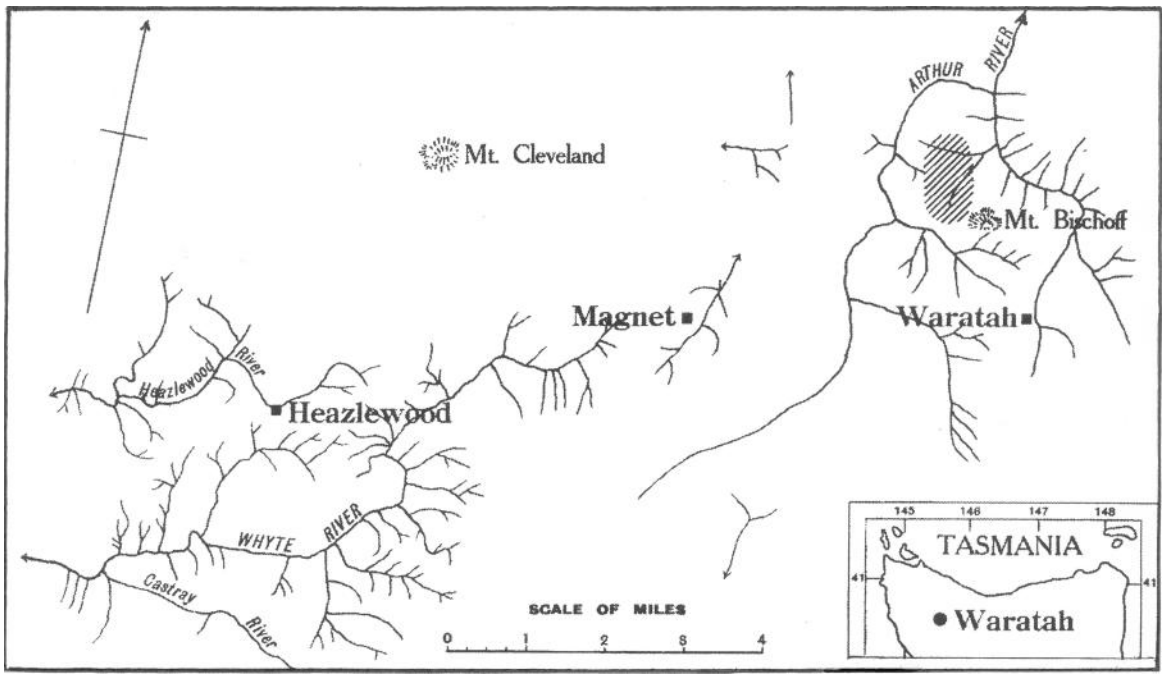
The Magnet Mine 1894-1940: 'careful management – constant production'

By KEITH PRESTON

An east-northeasterly trending zone of silver-lead mineralisation extends from Heazlewood to the Magnet mine and onto an area to the northwest of the Mount Bischoff tin mines in Tasmania (Fig. 1). The mine site was located towards the end of the Magnet Creek floodplain on the eastern side of the Magnet Range. This forms a broad northeast-southwest trending ridge above 600m elevation that separates the catchment of the southwesterly flowing Whyte River to the west from the northeasterly-flowing Magnet Creek on the eastern side. The latter forms one of the main tributaries in the headwaters of the Arthur River that flows northerly before swinging to the west to discharge into the Southern Ocean. All of the watercourses in the area are deeply incised and the steep valley sides densely forested, these factors presenting considerable problems when establishing mine access routes.

Figure 1: The *Magnet mine located within the unlabelled Magnet Creek valley, highlighting the incomplete mapping of the time*.



Source: L.K. Ward, 'The Silver-Lead Lodes of the Waratah District', GSREP2, December 1911, p. 3, Mineral Resources Tasmania.

In 1871, legendary prospector James (*Philosopher*) Smith was the first to explore the Arthur River headwaters, when the waterfall shown on Fig. 2 (at point 4) was discovered (later named Philosopher Falls in tribute). Although the Magnet lode eluded his attention, discovery of the extremely rich Mount Bischoff tin deposit led to the establishment of the Waratah mining settlement.[1] Prospecting of the remote

uninhabited area to the west of Waratah fuelled demand for improved overland access to potential mineral districts on the west coast. The Mount Bischoff and Donaldson Track Formation Association was established to raise funds, initially by public subscription, for prospector William Robert Bell to blaze a trail westward from Waratah over the Magnet Range towards Heazlewood and then southwest along the Whyte River to Corinna.[2]

Geologically, the Magnet orebody is associated with a large composite (ultramafic) dyke intruded between branching shear zones of variable inclination. The width of the dyke is approximately 400m at the mine site but diminishes along strike in the north-easterly direction. Orebody inclination varied from 55 degrees at shallow depth increasing to 70 degrees in the deeper mine levels. Extensive alteration and carbonatization of the host rocks increases towards the margins of the orebody.[3]

False Starts - 1880s

Prospector Bell had found silver-lead mineralisation adjoining the lease holdings of the North Bischoff Valley Tin Mining [TM] Co. by December 1879 when he applied for a 32ha section.[4] A prospectus for the Mount Bischoff Silver-Lead Mining Co. issued the following July made provision for a working capital of about £17,500 (less float expenses) within the first year and the retention of almost 42 per cent of the stock by the promoters. Bell and Philosopher Smith were listed among the provisional directors having a combined 8.35 per cent shareholding at registration.[5] Smith's judgement was held in high regard, attracting investors and experienced Cornish mine superintendent Captain James Hancock to oversee development work that was underway by June 1881,[6] but this had stalled two years later when Bell took control as mine manager. Despite further underground development in the following year, no economic deposits were found, and the lease and plant were advertised for disposal in February 1884.[7]

By 1882 indications of tin mineralisation towards the northern end of the Magnet Range prompted five leaseholders to form the Magnet TM Association in May of that year. Company registration followed but despite expending some £1,350 on development over a three-year period, no significant mineralisation was found and the leases were forfeited in November 1886.[8] These early failures discouraged further prospecting of the Magnet Range, the focus moving west to Heazlewood where economic silver-lead deposits were also discovered by Bell and Smith.[9]

Slow progress 1892-97

Bell's trail blazing to the West Coast in 1879 entered folklore due to discovery of the gossanous cap of the Magnet silver-lead lode that was located near to his campsite, an account that was re-told at a board meeting in 1907 by director Robert S. Scott:

> Mr Bell in an exploratory journey through the West Coast, camped on the very spot where the mine now is. Years afterwards he passed the same way and found some slabs of galena. He brought them to Mr Petterd and through them a company was formed. He [Scott] still retained one of those slabs.[10]

Over ten years passed before Bell's return in early 1891 to peg two 16ha claims (Leases 3706 & 3707-87M) to the north of a 8ha reward claim (Lease 3705-87M) and a further 16ha claim (Lease 3708-87M) to the south for William F. Petterd. Lease applications were lodged in February, surveys completed the following month and a year later Bell was reported to have 'commenced operations on his section'.[11] By February 1894 Bell with the assistance of his nephew Francis (Frank) Elliott had driven a 30m long adit to intersect the lode enabling 30.5t of ore to be stockpiled. A pack track was formed towards the newly metalled Waratah-Heazlewood road to the south to convey the ore to Waratah.[12] A meeting later in the month resolved to form a company and appointed four directors Bell, Petterd (chairman), Joseph C. Genders and Robert S. Scott who were largely responsible for developing the company over a 15-year period. Legal secretary George L. Meredith proceeded with registration of the Magnet Silver Mining Co. having a modest capital of £1,024, 84 per cent of the shares held by just four directors – Bell, Elliott, Petterd (each holding 24.2 per cent) and Robert Scott (11.4 per cent).[13]

Following the appointment of mine manager Elliott, a trial 12.2t parcel of ore was despatched to Hamburg for processing in April 1894. Further progress was stalled by a severe economic depression that affected Tasmania during the mid-1890s.[14] A visit by Melbourne metallurgist Dr. John Storer in July 1896 prompted despatch of a five tonne trial shipment to the Queensland Smelting Co. plant near Maryborough.[15] Further small 5-6t batches obtained by Elliott on tribute produced similar yields of 190oz and 54 per cent lead per ton, leading to the supply of machinery from Melbourne that arrived at Burnie in late December.[16] During the following eight months 50.8t of ore was despatched providing revenue of £1,000 but the transport costs were high - 27s 6d per ton for carting from the mine to the Waratah railhead of the Emu Bay Railway, a further £1 per ton for railing to the Burnie port.[17]

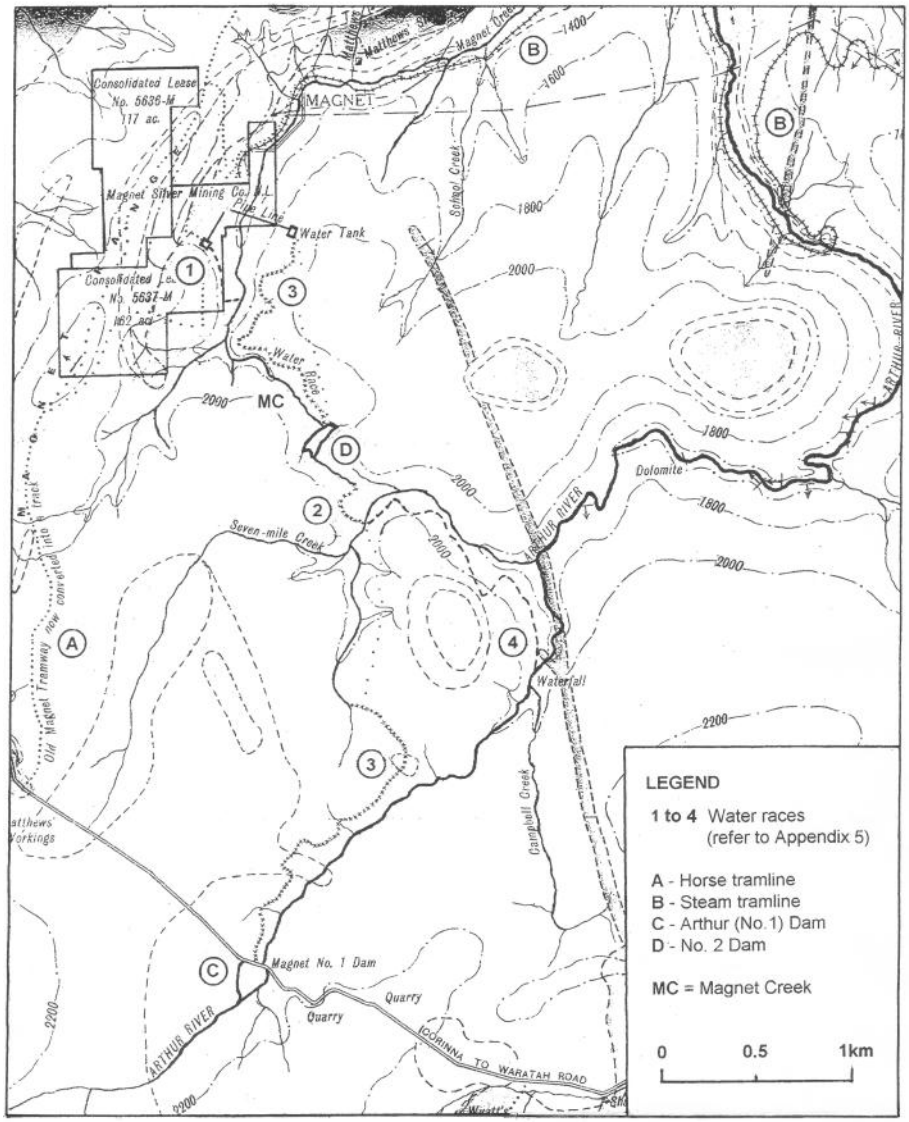
Improved access and production: the milling quandary 1897-1900

A shareholders meeting in December 1897 resolved to increase capital to £2,500 to fund mine development and although the combined holding of the three principle shareholders (Smith, Bell & Elliott) was diluted to 65.5 per cent, a substantial financial burden was shouldered to retain control.[18] A mine manager (Thomas H. Jones) was appointed and tenders were called for driving another adit (the No. 4 Level) from the valley floor, erecting drying kilns to reduce the moisture content of the gossanous ore, and surveying a 4.2km tramline to the Waratah-Heazlewood road.[19] Construction of the tramline was delayed however, most likely due to the considerable cost, and a corduroyed pack-track substituted. The director's caution in funding development largely from revenue can be attributed to the stigma of the failed Mount Bischoff Silver-Lead Mining Co. 15 years earlier.

Trial shipments of ore to the Smelting Co. of Australia Ltd plant at Dapto, Wollongong, NSW, commenced soon after the first of the water-jacketed furnaces was blown in on 6 September 1897, encouraged by favourable smelter charges of £1 per tonne (half that of the Queensland Smelting Co.), leading to a formal contract being

drawn up the following October. This agreement further reduced the contract price for smelting to 17 shillings per tonne.[20] Construction of the horse tramline (610mm gauge) could be delayed no longer – an application for an easement was registered in December and work completed five months later. The alignment had to be zig-zagged up the hillside in order to rise over 200m to the top of the Magnet range in a distance of approximately 1.5km.[21] To avoid a further capital raising, the £2,300 construction cost was funded by the principle shareholders.[22]

Figure 2: *Magnet lease holdings and access routes (circuitous route of steam tramline extending to the northeast) together with storage reservoirs and connecting water races (200ft contour intervals).*



Source: P.B. Nye, 'Geological sketch map of the Waratah District', Geological Survey Bulletin, no. 33, November 1922, Plate III (with additions), Mineral Resources Tasmania.

With the mine output set to increase to 102t per month by the end of 1899, the directors now had to address a requirement for a mill to produce concentrates from the second-class ore prior to shipment for smelting. An application for a water right to 5 sluice-heads from the Magnet Creek had been made in September 1896 but was not

pursued until plans for a mill had been finalised.[23] Survey of the 500m long water race from Magnet Falls (see Fig. 2) was underway in August and tenders were called two months later in preparation for construction to commence in November but then the project stalled.[24] The directors sought advice from Melbourne mining consultant A.T. Brown, and John Craze (highly regarded Cornish mine manager of the Zeehan-Montana Mining Co. at Zeehan) who recommended offsite ore treatment – thus delaying mill construction.[25] In anticipation of increasing ore shipments, and taking account of the limitations of the horse tramline, district surveyor David Jones was engaged to fix a direct tramline alignment northeast of the mine towards Mount Bischoff (Fig. 2). Civil engineer Sydney Throw was appointed to oversee the design and Richard F. Waller AMICE[26] engaged as construction manager for the 15.2km long 610mm gauge tramline utilising steam haulage.[27] Mines Department Geologist William Twelvetrees also visited the mine, recommending that the gossan ores continue to be smelted offsite but a mill be erected to produce concentrates from the sulphide ores.[28]

Steam tramline and power generation 1900-04

Financing for the proposed tramline now had to be sourced. Demanding engineering requirements for the severe gradients and tight curves resulted in a preliminary cost estimate of £15,000 (£20,000 including steam locomotives and rolling stock) – this exceeded the total expenditure of £18,000 to March 1900, of which over 80 per cent was sourced from ore sales.[29] As a temporary measure 15,000 additional shares were issued in June raising £1,500, thereby further diluting the holdings of the principle shareholders but the directors retained overall control due to the shareholding of the legal secretary. Funding for the tramline was largely raised by the issue in July of £15,000 trust shares, the directors taking 50 per cent and other shareholders the remainder. The share issue was over-subscribed despite the considerable risk associated with an unspecified repayment schedule from future revenue.[30] Construction was completed to budget in January 1902, remarkably only twelve months after Waller and assistant Frank K. Pitt commenced surveying the route, at a cost of £19,251 including £2,961 for rolling stock. A 9.6km section of unrelenting grades exceeding 1 in 35 (including 4.8km at a maximum grade of 1 in 25) was designed to avoid an expensive rack system that had been adopted by the Mt Lyell Railway for even steeper grades. Orenstein & Koppel supplied German locomotives, the larger 18.3t locomotive having an articulated frame (Mallet system) to handle the tight curves. Daily trips by the Mallet locomotive hauling 30.5t ore and the smaller 6.8t locomotive (15.25t) gave a monthly capacity of 1100-1200t for a 6-day working week.[31]

Although the decision to erect a mill was deferred, an ore drier and associated rock crusher, together with a source of power, were urgently required to reduce the moisture content of the first class ore prior to shipment. Construction of the water race from Magnet Falls resumed in April 1901 and was completed eight months later. This comprised a rock cutting and 12.2m long tunnel through a spur near the Falls, followed by a race contoured around the hillside to a pipe column providing a 79m pressure head

to the mine site (Fig. 2).[32] The ore drier fabricated to the mine's design was commissioned in May 1902, and comprised

> a cast-iron cylinder 24ft. long and 5ft. diameter which is mounted on friction rollers and revolved by gear wheels underneath. It is set up with a fall towards the furnace, and the heat from the fire passes through it, over the ore, and up the wrought iron chimney.[33]

It was driven by a 14.9kW pelton wheel and had a capacity of 51-61t per day, reducing the moisture content from 27 to 6.5 per cent.[34] The water supplied by a 125mm diameter pipeline was found to be adequate for driving a second pelton wheel that was coupled to a secondhand air compressor and used to operate a haulage winch and a Cameron pump, indicating that water inflows into the deeper workings were increasing.[35] Rock drills purchased for winze construction led to a demand for more compressed air – this in turn required additional water for increased power generation.[36] An application for 2 sluice heads from Seven Mile Creek (a tributary of the Arthur River – see Fig. 2) was registered in February, and construction of a 605m water race was underway within days, to be completed three weeks later. This merely diverted water from the Arthur River into Magnet Creek – a conduit already in use to supply the mine.[37]

Smelting issues and the first dividends 1902-05

Completion of the steam tramline halved the cost of conveying ore to Waratah to 14 shillings per ton and a substantial 80 per cent reduction (to 30 pence per ton) for freight onto Burnie was negotiated by Chairman Petterd with the Emu Bay Railway Co., based on the anticipated increase in output. Consideration was now given to offsite treatment of the low-grade sulphide ores that had been stockpiled. A lead smelter operated by the Tasmanian Smelting Co. and financed by the Deutsche Bank in collaboration with Metallgesellschaft, commenced at Zeehan in July 1899. American engineer Max Heberlein was engaged to oversee the plant construction adopting the Huntington-Heberlein process.[38] This was one of many processes implemented worldwide with variable results to treat sulphide ores associated with zinc blende at the turn of the 20th century, prior to the introduction of flotation. Petterd and mine manager Jones had inspected the Zeehan plant in December 1899 and a contract was awarded as soon as the steam tramline was completed in January 1902 for the treatment of 5,080t at a minimum rate of 254t per month.[39] This option became viable following the opening in December 1900 of the 78.35km long extension of the Emu Bay Railway southward to Zeehan, thereby minimising freight costs.

A further 5,080t contract with the re-formed Smelting & Refining Co. of Australia (1901) Ltd (at Dapto, NSW) for the gossanous ore was signed by Petterd in February and shipments commenced in May.[40] A rapidly increasing output to 1,016t per month by August 1902 enabled another contract to be signed for 18,290t with the British registered Sulphide Corporation of Australasia Ltd for smelting at their Cockle Creek plant (near Newcastle, NSW), and ore shipments commencing in the second quarter of 1903.[41] Ore sales during the first nine months of 1903 generated a revenue of

£21,813, enabling creditors to be repaid and the first one shilling dividend to be declared in November. This heralded a sustained four-year period of profitability when dividends amounting to £22,000 were returned to shareholders.[42] As a result of decreasing ore consignments, closure of the Dapto smelter in March 1905, forced the treatment of all gossanous ore to then take place at the Cockle Creek smelter.[43]

Mill erected - more water required 1905-07

Mine manager Edward A. Delatour commenced in October 1904 to oversee the installation of concentrating plant. Steam power was adopted to conserve water, with the 30kW engine and boiler being fabricated by the Salisbury Foundry at Launceston at a cost of £3,480.[44] Trials were underway on April 17th during a visit by directors Petterd and Genders, when the stockpiles had grown to over 6,910t.[45] The mill had a capacity of 50-65t per day from two-shift working, and approximately 5.5-7.5t of second-class ore was required to produce a tonne of concentrate grading 992gm silver and 10 per cent lead.[46]

The following summer was the 'driest season for eight years, resulting in a two week shut down of the mill, as there was insufficient water to operate the jaw crusher, or to undertake mine hoisting and pumping. This was anticipated, as survey work had commenced in October for a proposed water supply scheme that comprised a 68ML storage dam on the Arthur River and a 1,810m long supply race to connect with Seven Mile Creek (Fig. 2).[47] A requirement for the water race had been foreseen six years earlier when an application for 10 sluice heads from the Arthur River was registered (later reduced to 5 sluice heads), the detailed planning now being undertaken by manager Delatour with the assistance of the mine's surveyor Oliver L. Adams.[48]

Tenders were called in September 1906 for cutting the Arthur River race together with a 1,410m long *high level* race from Magnet Creek (Fig. 2) to a 510mm diameter pipe column to provide an increased 124.5m pressure head for power generation.[49] Components for a pipe column were manufactured by Mephan & Ferguson (of Melbourne), comprising 365m of 'patent spiral riveted' piping that was installed by the end of May when a 1.22m diameter pelton wheel arrived from D. Richardson & Son's Footscray (Melbourne) plant. The scheme commissioned on 4th June in time for the winter rains, saw savings in firewood and fireman's labour, reducing the annual operating cost of the mill by £1,200.[50] The existing boiler was utilised to supply a new steam shaft winder that commenced in July, driven by a tandem compound engine supplied by James Martin & Co. Ltd of Gawler, South Australia, which was also utilised to power a new Ingersoll Rand air compressor.[51]

Expansion and troubled times 1907-08

Further development outlined at the November shareholders meeting included additions to the milling plant to increase capacity to 762t per week (cost £4,036), increased storage capacity of the Arthur River reservoir to 127ML to 'ensure all the Peltons running full time during the dry weather' (£1,200), electric lighting for both the mill and mine (£400), and another 18.3t Mallet locomotive for the tramline to handle the

increased output (£1,680). Tenders for construction of the 11,470m^3 dam embankment were called in November, surveyor Adams supervising the team of 60 navvies that commenced two months later placing between 1,070-1,225m^3 of fill per week.[52] Installation of machinery in the mill was also underway in March and completed six months later, the design based on Broken Hill practice whereby tailings were treated in a second unit to achieve 75 per cent recovery.[53] Three additional pelton wheels (10.5, 50 & 64kW) supplied by D. Richardson & Son were utilised to power the mill.[54] Manager Delatour also planned to replace the Cameron steam pumps by Cornish drawlift pumps driven by a 1.22m pelton wheel. The additional demands on water supply and the £2,000 estimated cost of introducing an out-dated technology probably deterred its implementation.[55]

Dividend payments were halted in January 1908 due to the heavy expenditure, and a downturn in the metals prices was cited as the reason for discontinuing an 8 per cent wages bonus for the mine staff. Predictably, threatened strike action only abated after a site visit by chairman Petterd.[56] Further strike action was prompted in April by the dismissal of officials of the Amalgamated Mining Association and as calls for a return to work were rejected, drastic action was taken when Petterd 'ordered the pumps to be drawn'. By the end of the month the water level had risen 40.5m above the No. 8 Level (the lowest) 'the shaft now being more than half full of water'.[57] Work resumed on 2nd June when 40 non-union miners were engaged and pumping commenced at the rate of 2.275ML per day, resulting in the mine finally being de-watered by the end of the month.[58] The strike ended in November, the lost revenue leading to an increase of £1,000 in the nominal capital at a December shareholders meeting by the issue of a further 10,000 shares.[59]

A new management team 1908-14

Although the mill expansion lowered operating costs, increased water consumption following the switch from steam power resulted in summer shutdowns of mining operations in 1909 and 1910 that reduced both output and profit, thus highlighting the constraints associated with insufficient water storage. An auxiliary steam plant to maintain production was installed at a cost of £1,350 in time for the summer of 1911.[60] This was Petterd's final action, as his early death aged 60 in April 1910, robbed the board of a leader of high calibre. Bell had resigned 30 months earlier due to declining health and his nephew followed some six months later.[61] Joseph Genders who had provided substantial support and a wealth of experience based on his numerous directorships of mining companies, also resigned in mid-1909 aged 83, to be replaced by his son Arthur. Manager Delatour continued until November 1912 to provide some continuity.[62] Director Percy Hart (Bell's replacement) was promptly elected chairman; his immediate challenge being that of reducing a £7,000 overdraft, which exceeded the uncalled capital.[63]

With financial matters deteriorating, the company's first call since formation, sought to raise £2,500 in July 1911. The November shareholders meeting revealed a half-year loss of £3,709 and a rising debt to £10,000.[64] Increased production to

6,256.5kg silver was achieved in the half year to February 1911 with a 20 per cent increase in the workforce and above average summer rains. The resulting revenue of £39,288 enabled the overdraft to be cleared.[65] A dispute in August 1909 between the Zeehan smelter and its biggest supplier, the Hercules mine at Rosebery, led to its closure at the end of the year resulting in an increase in shipments to Germany to 60t a month.[66] A contract was negotiated by Adelaide metal broker Francis Snow (agent for Aaron Hirsch & Sohn of Frankfurt) for all concentrates to be shipped to Germany from March 1911, resulting in a 30-40 per cent reduction of smelting costs immediately prior to the outbreak of war.[67] Robert G. Hales replaced manager Delatour in December 1912 when operations continued to be constrained by reduced profit margins.[68]

WW1 impediments and recovery 1914-17

All production ceased at the beginning of August 1914 due to the suspension of the ore supply contract with Aaron, Hirsch & Sohn at the outbreak of war. The ministry of William (Billy) Hughes instigated the substitution of British and Australian interests to resume metal refining and the Australian Metal Exchange was established a year later to control the wartime export of base metals.[69] Although the Sulphide Corporation's Cockle Creek smelter continued to accept ore shipments, suspension of the German contract was a serious setback due to the loss of immediate income for ore shipments in transit to Europe.[70] Mining resumed in November following the negotiation of reduced daily wage rates but as the Government was paying similar rates for labourers employed on road construction, good miners were in short supply.[71] Wartime restrictions had an immediate impact on production during 1915, output of both silver and lead being reduced to 55 per cent of pre-war levels. (Appendix 1)[72]

The financial situation improved rapidly from a low point in December 1914 when nominal capital was increased by 50 per cent (to £10,000), and dividend payments resumed 18 months later aided by escalating wartime metal prices.[73] This payment of dividends was, however, premature, as the Sulphide Corporation increased smelting charges by 50 per cent following the completion of their contract in November. A dramatic increase in production to establish a record output of lead during 1917 (see Appendix 1) may be explained by the shipment of stockpiled ores as a short-term solution to fund dividend payments and maintain profitability.[74]

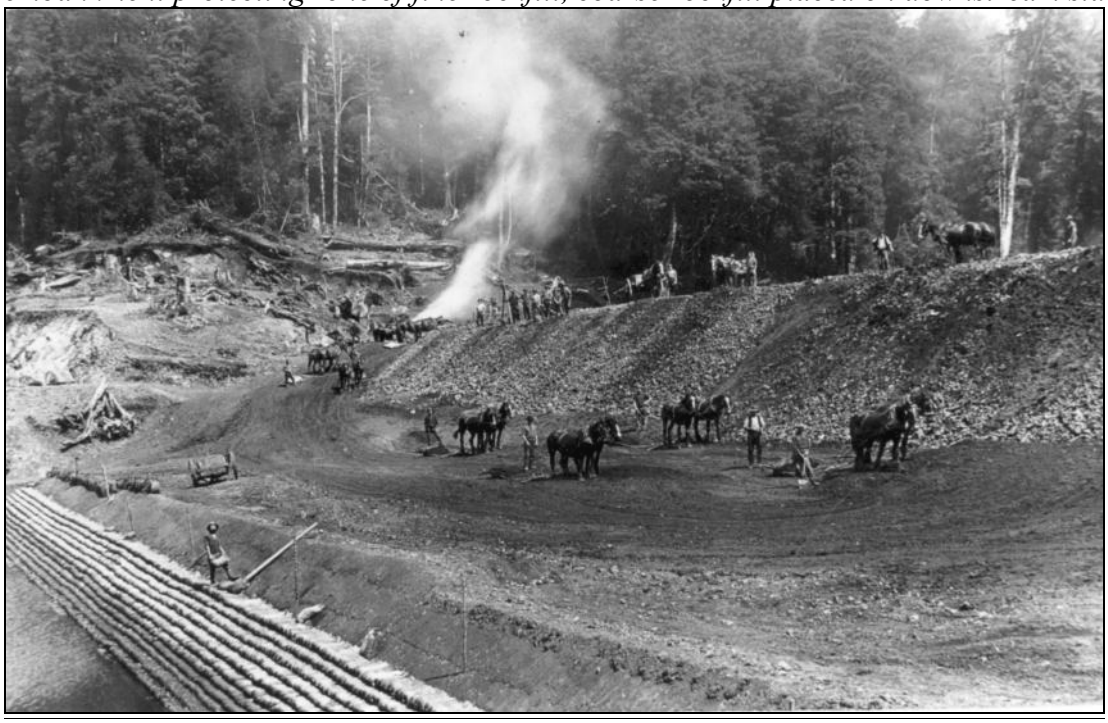
Increased water storage 1917-20

As summer shutdowns of both underground operations and the mill continued to reduce output, construction of a 364ML capacity storage reservoir (No. 2 Dam on Fig. 2) on Magnet Creek was announced at the November 1914 shareholders meeting, when it was revealed that the installation of a hydroelectric plant was also under consideration.[75] The previous board of directors had envisaged a requirement for the No. 2 Dam when the Arthur Dam was constructed – applications for a 6ha dam site and water rights to an additional 15 sluice heads being registered in October-November 1908 (Appendix 2).[76] As the design progressed, an application for a larger 28ha dam site was submitted in March.[77] Since supervising the Arthur dam construction, Oliver Adams had gained

considerable experience working as a civil engineer on north coast harbour works and the directors were fortunate in securing his services to oversee the new dam construction.[78]

Stripping of the embankment foundation to bedrock commenced in January 1917 but ironically, progress was slowed in February by an unusually high summer rainfall and by a shortage of labour due to men enlisting for the war effort.[79] A borrow pit was opened up in November[80] on the upstream side of embankment, overburden stripping during 1918-19 'being shifted with horses and drag scoops' in combination with 'wheel scoops' – no details of these are known.[81] Final preparation of the upstream face of the embankment included the placement of sandbags for protection against wave scour due to 'a great scarcity of suitable filling material' – large rockfill would have been a preferable option (Fig. 3). As the 'bagging' progressed in stages behind the formation of the embankment core, the water level was allowed to rise to sustain summer production.[82] By the beginning of October the water level had risen to 17.4m when a setback resulted from a section of the bagging (4-600 bags) slipping and blocking the outlet pipe. A diver from Burnie was required to clear the submerged bags and enable the reservoir to be drained. Consultant hydraulic engineer William R. Bell inspected the dam at the end of the month recommending that a steel outlet pipe be placed through the defective earthenware outlet pipe and the annulus grouted to prevent further leakage. Remedial work proceeded through the following spring enabling the reservoir to at last fill during the winter months of 1920 after a protracted 40-month construction period.[83]

Figure 3: *No. 2 Dam during construction – sandbag lining on the upstream face of the embankment protecting zone of fine rockfill, coarse rockfill placed on downstream side.*

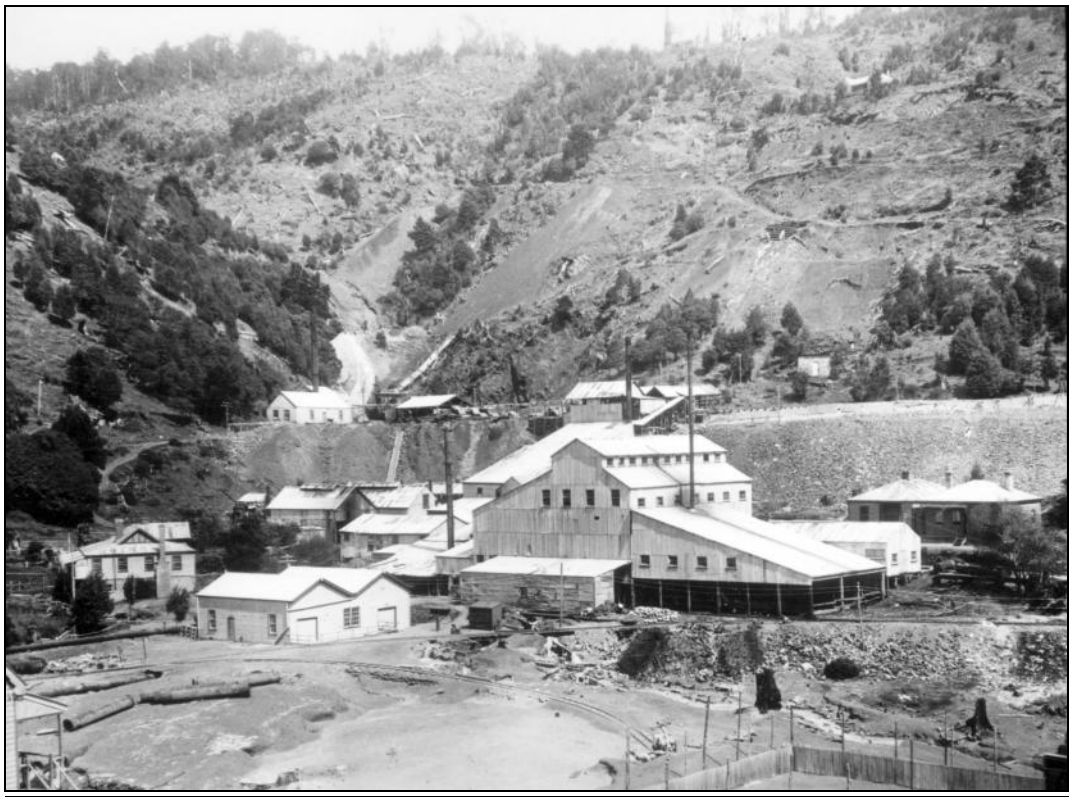


Source: Nic Haygarth collection.

Hydroelectric scheme

Development of the hydroelectric plant proceeded in tandem with the No. 2 Dam, the machinery being obtained following the closure of the Cassilis GM at Cobungra (near Omeo, Victoria) in September 1916. Tenders were called for disposal of the power plant in October but with no offers forthcoming, six months later, manager Hales was fortunate in acquiring the plant at auction.[84] The German power plant supplied in 1908 comprised a Voith pelton wheel of 500kW maximum output and 500kVA 3-phase alternator. As the Cassilis pipe column had a similar pressure head to that required at Magnet, this was also purchased.[85]

Figure 4: *Newly erected hydroelectric power station at lower left, the pipe column entering in the foreground where unused sections of the Cassilis pipe remain. The earlier pipe column (WR 124-93W) was located on the hillside at left.*



Source: Stephen Hiller collection courtesy Nic Haygarth.

The electrical plant had been shipped to Burnie in early September but took a further eight months to reach the mine from Cobungra because of concerns by the local Council over possible road damage.[86] An electrical engineer arrived in March to install the power plant, which was trialled nine months later after completion of the pipe column.[87] Delays with construction of the No. 2 Dam now prevented full implementation – tests of the electric motors supplied from Melbourne to drive the shaft winder and the first (of two) centrifugal electric pumps were not completed until November 1919. However, water supply shortages during the summer continued to limit output leading to an increase in operating costs when steam power was required to work the mill. For example, in 1921 when hydroelectric power generation resumed towards the end of March.[88]

Post WWI constraints 1918-22

Silver-lead mines in Australia experienced severe constraints immediately following the end of hostilities, the Tasmanian mines were particularly vulnerable due to the reduced scale of operations when compared with mainland mines. A protracted 17-month period of industrial disputes that commenced at the Broken Hill mines in April 1918 disrupted the supply of ore from the Sulphide Corporation's Central mine to the Cockle Creek smelter, leading to its closure eight months later.[89] Although the Sulphide Corporation stockpiled ore during the strike, paying an advance of 80 per cent of the metal price when the ore was delivered, final settlement three months after the smelter re-started in November 1920 coincided with a major slump in metal prices to a five-year low, resulting in mining companies having to refund the balance.[90] A Commonwealth Government embargo on the export of base metal ores was lifted in March 1920 but the unfavourable cost of freight to Europe of about £6 per ton compared to 17s 6d to Newcastle, NSW, prevented that option from being adopted until metal prices improved.[91]

Another setback late in 1919 resulted from the delayed arrival in Tasmania of the influenza pandemic that commenced at the beginning of 1918 in Europe and the USA. Despite a maritime quarantine being established in Tasmania, whereby all passengers and crew were monitored for at least 24 hours before disembarkation was permitted, the flu outbreak had reached the Magnet mine by the beginning of September.[92] A week later half the workforce was incapacitated, the epidemic described as 'dying out' by the 23rd of the month.[93] No deaths were reported at the Magnet township in spite of the state-wide total reaching 240.[94] Production was also hindered by labour shortages 'especially good miners … at no period of the year was the mine fully staffed'.[95]

All production was suspended for twelve months in March 1921 as a result of the downturn in the metal markets. This immediately followed the completion of the hydroelectric project at a cost exceeding £40,000 and led to a further (240 per cent) increase in nominal capital to £24,000 in July to meet outstanding financial commitments and ongoing maintenance.[96] The upturn in the metal market then coincided with a dry year – some 10 per cent below the 50-year mean value, the expensive new storage dam not being filled until mid-April. Steam power was used for milling in order to conserve water for essential mine pumping.[97] Another change of smelter was now required due to the impending closure of Cockle Creek brought about by the reduced output from the Broken Hill mines. This also affected the Port Pirie smelter, with owner Broken Hill Associated Smelters Pty Ltd offering reduced tariffs to encourage a trial shipment of Magnet ore in May. Port Pirie became feasible following the establishment of a zinc smelter from 1918 at Risdon on the Derwent Estuary by the Electrolytic Zinc Co. of Australasia Pty Ltd, when a shipping route from South Australia to Tasmania was established.[98]

Increased water storage but summer shortages continue 1923-26

Mine manager Hales had time to reflect on development issues during the 1921 shutdown, measures proposed at the June 1922 shareholders meeting for increasing the

water supply included raising the height of the embankment of the No. 2 Dam to 21.35m to provide an additional 204.5ML (total 568.5ML) and construction of a new water race from the Arthur River. Government Geologist Percival B. Nye suggested the race when he found that even in the driest period of 1922 there was a flow of approximately 50,000 gallons [227.3kL] per hour over Philosopher Falls. A race with a length of a mile or thereabouts was seen as the answer and when constructed could lead this water to the floodgate on the Seven-mile Creek' (see Figs. 2 & 5).[99]

Figure 5: *Water race formed in a rock cutting adjacent to Philosopher Falls (WR 2228W) – part of short section restored for use as a walking trail.*

Source: The author.

Work on increasing the height of the embankment commenced in September, the survey of the 2,135m long race was completed by the end of October and an application for 10 sluice heads lodged within days.[100] Cutting of the race commenced in December but was soon retarded by a record January (1923) rainfall of 264mm. Further record rainfall fell in May (584mm) and above average falls continued until November so that the rainfall total for the year (2,738mm) was 25 per cent above the 50-year mean value. This was a repetition of the Arthur Dam construction in 1907 – another example of unfortunate timing. The race was finished by 10th April when 5 sluice heads were flowing but four weeks later it was dry, as the April rainfall was abnormally light (only 7.5mm), highlighting the limitations of the relatively small catchment area of the Arthur River headwaters.[101]

Work on raising the dam embankment was completed in April and the water level was raised progressively to 20.9m to take advantage of the high rainfall.[102] This provided the directors with the confidence to re-commence dividend payments, and shareholders consequently received three dividends amounting to £9,000.[103] Although rainfall in 1924 was again above average, and despite both dams being full at the beginning of December, six weeks later, the hydroelectric power plant was reduced to single shift working to conserve water for pumping – the water storage capacity remaining inadequate for continuous operation.[104] The main shaft was extended by 61m during the first half of 1925 to develop the lower levels of the orebody but additional pumps were soon required for the increased water inflows, raising the pumping capacity to 163.6 kL/hr. This placed increasing strain on water availability for power generation, leading to prolonged use of the auxiliary steam plant in summer, associated with a rise in operating costs.[105] No reference has been found to the mine water being re-cycled for ore processing – a serious oversight if not implemented to conserve supplies.

Detailed water consumption figures are not available but approximate values can be calculated based on the time taken to reduce the dams from full capacity to having only a reserve to keep the pumps operating. In January 1908 the original Arthur Dam (capacity 127ML) was reported as 'equal to a month's supply of water for the full

running of the machinery' then utilised for ore drying and processing, and driving the small air compressor. For two-shift working this indicates a consumption rate of approximately 255kL/hr, which compares favourably with 410kL/hour for the much larger Mount Bischoff mill in 1914.[106] Following the completion of the hydroelectric power plant, the storage dams were consistently reduced to the reserve level in 38-40 days.[107] Assuming seven-day working and a reserve of 10 per cent to ensure continuous pumping, this indicates a daily consumption of approximately 17ML, or 1-2ML per hour for one or two-shift working.[108] This again compares favourably with a rate of 2.5ML per hour at Mount Bischoff where the power plant had a similar output to that at Magnet. The Magnet storage capacity was, however, only a third of that at Mount Bischoff, which explains the summer shutdowns, and by 1926, Manager Hales became critical of the water shortages, claiming that alternative sources should have been tapped. Later topographical mapping does not support this, for the rivers to the east were fully utilised by the Mount Bischoff mines and the Whyte River to the west by the Cleveland mine, which was also water-powered.[109]

Final phase 1926-32

A deteriorating balance sheet in 1928 led to Ralph D. Nevett (former mill superintendent of Mount Morgan GM Co.) being engaged to undertake long overdue trials of zinc recovery from the tailings by flotation, leading to a recommendation to commit £15,000 on plant, but this sum was unavailable.[110] The following year chairman Hart and legal secretary Meredith (after 39 years service) resigned – Meredith the final member of the original management team, as Robert Scott had resigned in 1923 at the age of 86.[111] Water shortages continued, prompting the preparation of design drawings for a further increase in height of the No. 2 dam embankment by a further 3m but again no finance was available.[112] A £3,500 Government loan secured against the property was obtained following annual losses in 1929 and 1930 to purchase additional steam plant and electrical equipment from Launceston City Council.[113] Low metal prices during the first ten months of 1932 forced closure and the retirement of manager Hales after 52 years in the mining industry.[114]

Revival attempts

Agreement was reached between the liquidator and the Magnet Prospecting Syndicate in June 1932 for tribute working as a co-operative venture, led by Charles V. Hugo, the former legal secretary. Annual reports for 1933 and 1934 reveal that the mine barely paid its way, and with no opportunity for investment during the Great Depression the venture folded at the end of the year when water supplies were exhausted.[115] The New Magnet Prospecting Syndicate was formed in October led by miner Percy Thomas to re-commence work with the aid of a £4,185 Government grant. Limited production (Appendix 1) led to a further failure two years later when the township population had fallen to 37 and houses were being dismantled.[116] The mine was purchased in April 1937 by Melbourne-based Amalgamated Goldfields Estates and a prospectus for the Magnet Silver-Lead Mines issued a month later, the promoters including chairman

Leslie W. Hanson (Melbourne investor), Wilfred R. Snow (Adelaide metal broker), Edmund B. Genders (former chairman Magnet Silver Mine Co.) and Joseph Darling MLC. The nominal capital of £50,000 included £10,000 for payment to the owners and Government liquidator.[117]

Mine manager, A. Weaver Wincey (MAusIMM), was handed a substantial £17,700 budget to refurbish the main shaft, dismantle the old mill and install new equipment that included a ball mill and flotation plant. This occurred some 15 years after an initial recommendation by manager Hales.[118] Electric motors were installed in the new mill to ensure that production continued in summer, a move that should have been implemented earlier following installation of the hydroelectric plant to conserve stored water. In another irony of timing, good summer rain filled the dams in January 1938 but the mill was not operational until mid-August after an expenditure of about £25,000.[119] Manager Wincey had entertained prospects of developing a 'mother lode' but unprofitable working resulted in closure for the final time in March 1940 when 100t zinc concentrate remained unsold.[120]

Conclusion

The early development of *The Magnet* was retarded during the economically depressed 1890s by the high cost of providing access to the isolated mine site. At the dawn of the 20th century a very capable management team, ably led by chairman Petterd, backed their judgement by privately financing key infrastructure projects, such as the steam tramline. A 1926 newspaper article attributed the continued financial success of the mine to 'careful management – constant production', all of the prolonged shutdowns were caused by factors beyond their control: such as the outbreak of war, smelter stoppages, metal price slumps and to a large extent, water shortages.[121] Water supply was a critical factor in maintaining profitability, the enforced use of steam power for generation during summer a function of the limited water catchment areas available for storage reservoirs. Operating restrictions during WW1 and the Broken Hill industrial conflict following immediately afterwards had a devastating impact on momentum, leading to a dramatic fall in output and profitability. Mine management was also a victim of unfortunate timing, completion of major infrastructure to increase water storage capacity by 380 per cent in 1921 coinciding with a severe metal price slump. When production resumed, a brief period of profitability and final phase of dividend payments was followed by a steady decline that ended during the Great Depression. Implementation of an efficient recycling scheme for mine water and the earlier use of electric motors in the mill should have ensured that stored water was conserved solely for the hydroelectric plant, thereby maintaining profitability through the 1920s when operating conditions were particularly challenging.

The final investment involved in re-equipping the mill for the introduction of flotation processing in 1938 must be considered a gamble in the absence of a reliable estimate of ore reserves, the higher-grade deposits having been mined out by the initial company. Although the tailings dumps were re-worked for unrecovered zinc, no additional economic deposits have been delineated since the 1940 closure.[122] The silver-

lead output summarised in Appendix 1 is largely based on MRT published data, a detailed record available for 1909-22 but only fragmentary records for other periods. While the amounts appear reasonable when compared with data from annual company reports for silver, the interpreted lead output calculated for April 1901 - August 1909 is anomalous, leading to the conclusion that the lead output was overstated in MRT reports. The silver output exceeded that of the largest producing mines on the Zeehan field and the North Farrell mines at Tullah – *The Magnet* appropriately acclaimed as Tasmania's most productive silver mine, until surpassed by the Hellyer mine in the 1990s.[123] Lead output, however, was exceeded by both the largest producing Zeehan mines and the North Farrell mines, thereby validating the 1900 assessment of orebody geochemistry by Government Geologist William Twelvetrees who noted that 'The ratio of silver to lead in the Magnet is singularly constant, being 3 to 4 silver to 1 unit of lead. This is a higher ratio than in any other mine in the Colony. The ratio of the Zeehan field is one or two of silver to the unit of lead'.[124]

Acknowledgements

The assistance of AMHA member Greg Dickens with drawing searches and the supply of plan copies by Mineral Resources Tasmania [MRT] is gratefully acknowledged. Interpretation of the MRT mineral charts and site photographs was greatly assisted by Anne McConnell [with Nic Haygarth], 'An archaeological assessment of the Magnet Mine, Waratah Area, Northwest Tasmania', report prepared for MRT, ASR2013-2, Hobart, August 2013.

Appendix 1: *Production Summary*

Company & Date	Silver (kg)	Lead (t)	Comments
Magnet SM Co.			
8/1896 - 2/1901	6,630.5	603	
2-1902 - 8/1902	3,508.6	313	All ore shipped for processing
8/1902 - 2/1903	6,982.1	590	Record silver output
2/1903 - 8/1903	6,967.4	530	
2/1904 - 8/1904	4,897.7	507	
8/1904 - 2/1905	5,522.2	574	Mill commenced 6/1905
8/1914 - 8/1915	4,398.9	680	
8/1915 - 8/1916	6,061.0	1,012	
8/1916 - 8/1917	8,927.0	1,745	Record lead output
2/1901 - 8/1909	81,237	13,279	Average 9,752kg/year silver - 1,594t/year lead?
8/1909 - 8/1917	64,130	9,240	Average 8,016kg/year silver - 1,155t/year lead
8/1917 - 8/1922	15,940	3,231	Average 3,188kg/year silver - 646t/year lead
8/1922 - 6/1932	51,324	8,785	Average 5,131kg/year silver - 879t/year lead
TOTAL	207,404	35,541	
Magnet & New Magnet Prospecting Syndicates			
6/1932 - 3/1935	7,654.5	1,707	Average 2,552kg/year silver - 569t/year lead
11/1935 - 10/1936	739.4	144	
Magnet S-L Mines			
8/1938 - 3/1940	10,425	602	Average 521.2kg/month silver - 30t/month lead
TOTAL	226,222	37,993	

Appendix 2: *Summary of Water Rights*

Ref. No.[1]	Fig 2 Ref. No.	Source	Application Date	No. SH[2]	Length (m)	Construction Date
Low Level						
124-93W	1	Magnet Ck	25/9/1896	5	c500	4-12/1901
208W	2	Seven Mile Ck	11/2/1904	2	605	2-3/1904
944W			11/11/1908	7		
High Level						
399-93W	3	Arthur R	19/8/1899	5	3,220[3]	9/1906-3/1907
16W			26/8/1901	5		
943W			1/11/1908	8		
2228W	4	Arthur R	3/11/1922	10	2,135	12/1922-4/1923
			TOTAL	42		
Dams						
509W	5	Arthur R	21/1/1906	16ha	Not applicable	12/1907-3/1908
939W	6	Seven Mile Ck	22/10/1908	12ha		12/1916-7/1920
1837W			9/3/1917	28ha		9/1922-4/1924

Notes:
(1) Mines Department registers of water race applications (TAHO MIN90).
(2) SH = Sluice-head, equal to 0.68 cubic metres per minute or 41.1 kilolitres per hour.
(3) 1810m section from Arthur River dam to Seven Mile Creek & 1410m section from No 2 Dam.

Endnotes

[1] Nic Haygarth, 'Richness and prosperity: the life of W.R. Bell, Tasmanian mineral prospector', *Papers & Proceedings Tasmanian Historical Research Association* [hereafter *THRA*], vol. 57, no. 3, December 2010, p. 218.
[2] *Examiner*, 29 June 1900, p. 7; Nic Haygarth, 'Richness and prosperity…', p. 222.
[3] V.M. Cottle, 'Magnet Silver-Lead mine', *Proceedings 5th Empire Mining & Metallurgical Congress*, vol 1, 1953, p. 1140; D.I. Groves & M. Solomon, 'The geology of the Mt Bischoff district', *Papers & Proceedings Royal Society of Tasmania*, vol. 98, 1964, pp. 9-11, 19-20; P.B. Nye, 'The Silver-Lead deposits of the Waratah District', *Geological Survey Bulletin*, no. 33, November 1922, Plate XXV.
[4] 'Register of the issue of mineral leases', MIN120/1/1, Lease 634, 1 January 1879, *Tasmanian Archives & Heritage Office* [hereafter *TAHO*]; *The Mercury*, 24 July 1880, p. 1.
[5] 'Applications by mining companies for registration', MIN66/1/89, 14 January 1881, *TAHO*.
[6] *The Mercury,* 24 July 1880, p. 1; see *Launceston Examiner*, 27 May 1898, p. 3 for details of Captain Hancock's mining career in Tasmania following his departure from Moonta in 1878.
[7] *Launceston Examiner*, 3 June 1882, p. 3; *ibid*., 9 May 1883, p. 2; *The Mercury,* 29 February 1884, p. 1; *Hobart Gazette*, 7 October 1884, p. 1399: notice of forfeiture of 32ha Lease 634.
[8] *The Mercury,* 17 May 1882, p. 3; *Launceston Examiner,* 20 July 1883, p. 1; *ibid*., 4 August 1886, p. 3; *Hobart Gazette*, 2 November 1886, p. 1627 – notice of forfeiture of Leases 2211 to 2213, 794M & 795M, 1 April 1885.
[9] J.H. Smith, 'Report on the mineral district between Corinna and Waratah', OS128, July 1897, pp. 7 & 8, *Mineral Resources Tasmania* [hereafter *MRT*]; *THRA*, vol. 57, no. 3, December 2010, p. 228.
[10] *Daily Telegraph*, 25 May 1907, p. 4; William F. Petterd: a naturalist, elected member Royal Society of Tasmania in July 1881, later studying geology (specialising in mineralogy), *Australian Dictionary of Biography* [hereafter *ADB*], vol. 5, Melbourne University Press, 1974, pp. 441-42.
[11] 'Registers of applications for mineral leases', MIN83/1/7, 16ha Leases 3706 & 3707-87M, 8ha Lease 3705-87M WR Bell & 16ha Lease 3708-87M, W.F. Petterd, 16 February 1891, *TAHO*; *Wellington Times*, 26 March 1892, p. 2.
[12] *Launceston Examiner,* 13 February 1894, p. 7; *ibid*., 27 November 1891, p. 3; *ibid*., 8 March 1892, p. 4: funding of £10,000 for the Waratah-Heazlewood Road legislated November 1891, 16.9km section from Waratah through the Magnet Range summit metalled by March 1892 apart from a 4.8km corduroyed section (tree trunks laid transversely).
[13] *Daily Telegraph,* 24 February 1894, p. 4; *The Mercury* 27 February 1894, p. 1; for Bell see *THRA*, vol. 57, no. 3, 2010, pp. 203-35; for Petterd see *ADB*, vol. 5, 1974, pp. 441-42; for Genders see *Examiner*, 2 November 1935, p. 6; *ibid*., 30 June 1914, p. 5; for Scott see *The Cyclopedia of Tasmania*, vol. 1, 1900, p. 79; *Daily Telegraph*, 29 July 1924, p. 6; for Meredith see *The Cyclopedia of Tasmania*, vol. 2, 1900, p. 131.
[14] *The Mercury*, 20 April 1894, p. 7; H. Reynolds, *A History of Tasmania*, Cambridge University Press, 2012, p. 203.
[15] *Journals of the House of Representatives, Tasmania* [hereafter *TPP*], vol. 33, no. 66, July 1895, p. 18; *Daily Telegraph* 13 July 1896, p. 3; *Brisbane Courier*, 13 March 1889, p. 5; *ibid*., 7 May 1904, p. 15: Queensland Smelting Co. Ltd formed in London in July 1888 with nominal capital £80,000, following ore roasting and heating in a blast furnace, separation of gold and silver from lead by the Parkes process.
[16] *Launceston Examiner*, 3 September 1896, p. 3; *ibid*., 30 December 1896, p. 2; *The Mercury*, 24 December 1896, p. 3.
[17] 'Report of the Secretary of Mines', 1896-97, *MRT*, p. lii; 'The Progress of the Mineral Industry of Tasmania', MININD1899-1, March 1899, *MRT*, p. 10.
[18] *Launceston Examiner*, 16 December 1897, p. 8.
[19] *Ibid*., 5 January 1898, p. 3; *ibid*., 19 March 1898, p. 12; MININD1898-2, June 1898, *MRT*, p. 8.
[20] *Sydney Morning Herald*, 6 January 1896, p. 7: Smelting Co. of Australia acquired the N.S.W rights to the patent of Dr. John Storer and Walter Marsh (manager of BHP Co. Ltd) for an improved method of treating sulphide ores; *ibid*., 7 September 1897, p. 7; *Launceston Examiner*, 15 November 1897, p. 3; *ibid*., 31 March 1899, p. 3; *ibid*., 29 September 1899, p. 3; *The Mercury*, 1 October 1898, p. 4; for description of the original Smelting Co. of Australia plant see 'The Smelting Works at Dapto', *Australian Mining Standard* [hereafter *AMS*], 31 March 1898, pp. 2799-2801.
[21] 'Registers of applications for water rights', MIN90/1/3, 3.6m wide tramline easement as WR 270-93W, *TAHO*, 9 December 1898; *Launceston Examiner*, 31 March 1899, p. 3; *ibid*., 30 June 1899, p. 3.
[22] *Daily Telegraph*, 16 August 1905, p. 6.
[23] *Launceston Examiner*, 1 December 1899, p. 2; MIN90/1/3, 10 SH as WR 270-93W, 25 September 1896, *TAHO*.

[24] *Ibid*., 28 October 1899, p. 12; *ibid*., 20 November 1899, p. 2; *Daily Telegraph*, 15 August 1906, p. 2.
[25] For Craze see *The Cyclopedia of Tasmania*, vol. 1, 1900, p. 534; *Zeehan & Dundas Herald*, 13 January 1899, p. 3: A.T. Brown referred to as 'the Victorian expert, alias *Condemnatory Brown*'.
[26] Associate Member of the Institution of Civil Engineers (London).
[27] *Examiner*, 30 March 1900, p. 3; *ibid*., 28 September 1900, pp. 2-3; *ibid*., 21 December 1900, p. 6.
[28] W.H. Twelvetrees, 'Report on the Mineral Fields between Waratah and Corinna', OS158, 6/1900 p. 20, *MRT*.
[29] *Examiner*, 30 March 1900, p. 3; *ibid*., 28 September 1900, pp. 2-3.
[30] *Ibid*., 28 June 1900, p. 1; *ibid*., 23 May 1907, p. 4; *Daily Telegraph*, 16 August 1905, p. 6; *Examiner*, 5 July 1911, p. 2: legal secretary Meredith held a 3 per cent stake (1500 shares).
[31] *Examiner,* 23 May 1902, p. 2; R.F. Waller,' The Magnet Tramway', OS193, 30 June 1902, *MRT*; see *Zeehan & Dundas Herald*, 'Impressions of Waratah', 6 October 1902, p. 2 for an amusing account of travel on the Magnet Tramway.
[32] *The Mercury*, 15 April 1901, p. 4; *Examiner*, 9 December 1901, p. 2; *ibid*., 18 September 1905, p. 2; *Daily Telegraph*, 28 December 1903, p. 7.
[33] *The North Western Advocate*, 30 May 1902, p. 2; *Examiner*, 13 December 1902, p. 6.
[34] MININD1902-2, 30 June 1902, p. 10; *Zeehan & Dundas Herald*, 1 December 1902, p. 4; *Daily Telegraph*, 15 December 1902, p. 6; *Examiner*, 30 November 1905, p. 2.
[35]*Examiner*, 30 May 1903, p. 6; *ibid*., 11 September 1903, p. 2; *Daily Telegraph*, 9 September 1903, p. 5; *ibid*., 28 December 1903, p. 7; MININD1903-3, 30 September 1903, p. 11, *MRT*.
[36] *Examiner*, 11 September 1903, p. 2; P.G. Tait, 'Around the Tasmanian mines', *Mining & Engineering Review*, April 1913, p. 280.
[37] MIN90/1/3, 2 SH as WR 208W, 11 February 1904, *TAHO*; *Examiner*, 9 March 1904, p. 2.
[38] *Examiner*, 30 March, p. 3; W. Poole, 'The Treatment of Broken Hill ores', *Journal & Proceedings Sydney University Engineering Society*, vol. 13, 1908, p. 107: Huntington-Heberlein process adopted by BHP Co. Ltd at Port Pirie, & Chillagoe Mining & Railway Co's works in addition to Zeehan & Cockle Creek; for a detailed description of the Tasmanian Smelting Co. operations see D. Clark, *Australian Mining and Metallurgy*, Critchley Parker, 1904, pp. 228-3; for the 'sulphide problem' see G. Blainey, *The Rise of Broken Hill*, Macmillan, 1968, pp. 51-54, 68-77.
[39] *Launceston Examiner*, 1 February 1899, p. 2; *Examiner*, 23 January 1902, p. 2.
[40] *Zeehan & Dundas Herald*, 19 December 1900, p. 2: construction of the Emu Bay Railway from Guildford Junction to Zeehan took 38 months to complete at a cost of £450,000; *Examiner*, 13 February 1902, p. 2; *ibid*., 29 April 1902, p. 3.
[41] *AMS*, 22 October 1903, p. 556: output for half-year ending August 1902 – 3346.4t yielding 3508.5kg silver & 313t lead, ending February 1903 – 7150.2t yielding 6982kg silver & 590t lead; for the Sulphide Corporation see G. Blainey, pp. 67-68 & 78-79; E. Eklund, 'Managers, workers and industrial welfarism: management strategies at the Electrolytic Refining & Smelting Co. of Australia Ltd and the Sulphide Corporation, 1895-1929', *Australian Economic History Review*, vol. 37, no. 2, July 1997, pp. 140-41: originally formed as the Sulphide Corporation (Ashcroft's Process) Pty Ltd in October 1895 by a group of Australian and British investors; see D. Clark, pp. 428-41 for a description of the Sulphide Corporation processing plant.
[42] MININD1902-3 to 1903-3 for the quarters ending September 1902 through to September 1903, *MRT*.
[43] *Australian Town & Country Journal*, 8 March 1905, p. 54; *Examiner*, 1 June 1905, p. 2.
[44] MININD1904-3, September 1904, p. 12, *MRT*; *Daily Telegraph*, 6 October 1904, p. 6 *ibid.,* 10 May 1905, p. 6: Delatour previously assistant manager at the Hercules Gold & Silver Mining Co.; *Daily Telegraph*, 11 October 1904, p. 8; *Examiner*, 5 January 1905, p. 1; *ibid*., 30 November 1905, p. 2.
[45] *Examiner*, 12 April 1905, p. 2; *ibid*., 6 May 1905, p. 1.
[46] *The Mercury*, 10 May 1905, p. 7; *Examiner*, 1 June 1905, p. 5.
[47] *Ibid.,* 20 October 1905, p. 3; *ibid*., 17 November 1905, p. 6; MININD1905-4, December 1905, p. 12, *MRT*; *North Western Advocate*, 5 January 1906, p. 3; *ibid*., 10 January 1906, p. 2; 'Results of rainfall observations made in Tasmania', *Commonwealth Bureau of Meteorology*, 1936, p. 86: 'driest season' claim supported by rainfall records as 230mm recorded for December to February compared to 137mm in 1897-98.
[48] MIN90/1/3, 10ha dam site as WR 509W, 21 February 1906, *TAHO*; *ibid*., 10 sluice heads as WR 399-93W, 19 August 1899: the survey plans lodged 23 March 1906.
[49] *North Western Advocate*, 22 September 1906, p. 2; *The Mercury*, 5 April 1907, p. 2; NS1971/1/42: pipe column pressure head 124.65m, *TAHO*.
[50] *Examiner*, 5 June 1907, p. 2; *Advocate***,** 6 July 1921**,** p. 4: pipe column length reported as 350m.

[51] *Ibid*., 1 July 1907, p. 2; *ibid*., 30 May 1912, p. 2; 'Plans and drawings of mill machinery, water supply and tramway at the Magnet Mine', NS1971/1/48: blueprint by James Martin & Co. Ltd shows a tandem compound engine with 355mm + 585mm cylinders and compound air compressor 340mm + 570mm cylinders, both of 760mm stroke, 16 July 1907, TAHO; *Advocate*, 6 July 1921, p. 4: Ingersoll Rand compressor capable supplying 13 rock drills.
[52] *Ibid*., 30 November 1907, p. 4; *ibid*., 6 November 1907, p. 2; *ibid.,* 4 February 1908, p. 2; *ibid*., 30 November 1916, p. 2; *The Mercury*, 20 January 1908, p. 5; *ibid*., 24 March 1908, p. 6; NS1971/1/64: cross section of dam embankment shows downstream batter 1:1.5 – upstream 1: 2, width at base 27.5m, width at crest 3.05m.
[53] *The Mercury*, 24 March 1908, p. 6; *Examiner*, 7 September 1908, p. 2.
[54] *Daily Telegraph*, 24 June 1909, p. 2; 'Around the Tasmanian Mines – Part I', *Mining & Engineering Review*, v. 5, April 1913, pp. 279-81.
[55] *Ibid*., 30 November 1907, p. 4; NS1971/1/150: arrangement of two 8" plunger workings and one 6" drawlift workings' prepared by Hawke & Co. of Kapunda (South Australia), 1 August 1907, *TAHO*.
[56] *North Western Advocate*, 27 May 1908, p. 4; *Examiner*, 15 January 1908, p. 2; *The Mercury*, 20 January 1908, p. 5.
[57] *Daily Telegraph*, 7 April 1908, p. 2; i*bid*., 28 April 1908, p. 2; *Examiner*, 10 April 1908, p. 2.
[58] *Ibid*., 2 June 1908, p. 2; *ibid.*, 12 June 1908, p. 2.
[59] *Ibid*., 27 July 1908 (2c); *Mining Engineering Review*, v. 1, Nov 1908, p. 58; *The Mercury*, 12 December 1908, p. 8.
[60] *Examiner*, 24 June 1909, p. 2: mine shut down completely for eight weeks, partially for 18 weeks; *ibid*., 30 November 1910, p. 2; *Zeehan & Dundas Herald*, 21 January 1910, p. 4.
[61] *Ibid*., 30 November 1907, p. 4; *ibid*., 23 May 1908, p. 10; *Daily Telegraph*, 18 April 1910, p. 5.
[62] *Daily Telegraph,* 1 July 1909, p. 2; *North Western Advocate,* 30 November 1912, p. 5.
[63] *Examiner*, 28 April 1910, p. 1; *ibid*., 5 July 1911, p. 2.
[64] *Ibid.,* 26 July 1911, p. 8; *The Mercury*, 24 November 1911, p. 3.
[65] *Geological Survey Bulletin*, no. 33, pp. 170-71, *MRT*; MININD1910-3, September 1910, p. 12; *ibid.,* MININD1910-4, December 1910, p. 12, *MRT*.
[66] *Examiner*, 8 November 1909, p. 2; *ibid*., 1 December 1909, p. 2; *ibid*., 16 December 1909, p. 2.
[67] *The Argus*, 14 January 1915, p. 8: Francis Snow also negotiated contracts between March 1906 & August 1913 with Broken Hill Junction North & Block 10 Co's, Electrolytic Refining & Smelting Co (Port Kembla, NSW), Wallaroo & Moonta Co, Mount Morgan Co; Eklund, p. 141: Aaron Hirsch & Sohn one of three large German cartels that largely controlled the output of Australian lead and zinc pre-WW1; smelting costs reported in *Examiner*, 30 November 1910, p. 2; ibid., 30 May 1912, p. 2; *The Mining & Engineering Review*, vol. 5, July 1913, p. 418.
[68] *Examiner*, 30 May 1913, p. 2: Robert Hales previously the underground manager.
[69] *Daily Telegraph*, 7 August 1914, p. 6; see Eklund, pp. 148-49 for the impact of the outbreak of war on Australian metal refining companies.
[70] *Ibid*., 10 August 1914, p. 7; ZDH, 15 August 1914, p. 1; *Daily Telegraph*, 5 August 1921, p. 8: £3,000 remained unpaid for pre-war ore shipments.
[71] *Daily Telegraph*, 23 November 1914, p. 4; *ibid*., 10 March 1915, p. 2.
[72] *Geological Survey Bulletin*, no. 33, pp. 170-71.
[73] *Examiner*, 4 December 1914, p. 2; *The Mercury*, 1 June 1916, p. 1: first of six 1 shilling dividends paid through to September 1917.
[74] *TPP*, vol. 77, no. 7, May 1917, pp. 11 & 12: record lead output produced a dramatic increase in revenue to £70,601 during the year ending February 1917; *Examiner*, 1 June 1917, p. 2; *Geological Survey Bulletin*, no. 33, pp. 170-71.
[75] *Examiner*, 18 November 1916, p. 4; *Geological Survey Bulletin*, no. 33, p. 168.
[76] MIN90/1/4, 6ha dam site as WR 939W, 22 October 1908; 8 SH from Arthur River as WR 943W & 7 SH from Seven Mile Creek as WR 944W, 11 November 1908, *TAHO*.
[77] MIN90/1/5, 28ha dam site as WR 1837W, 9 March 1917, *TAHO.*
[78] *Examiner*, 30 November 1916, p. 2; for Oliver Adams harbour works see *Examiner*, 24 February 1913, p. 5; *ibid*., 14 February 1914, p. 4; *ibid*., 9 February 1915, p. 4.
[79] *Ibid*., 30 November 1916, p. 2, *ibid*., 1 June 1917, p. 2; *TPP*, v. 77, no. 7, May 1917, p. 11.
[80] This is the source of the fill (generally weathered rock) used in a dam embankment - as the name suggests often obtained by excavating a pit or small quarry depending on the amount required.
[81] *Examiner*, 29 September 1917, p. 4; *ibid*., 16 November 1917, p. 2; *ibid*., 23 January 1918, p. 2.
[82] *Advocate*, 5 April 1926, p. 10: 52,000 'old ore bags filled with fine earth' used.

[83]; *Examiner*, 15 October 1919, p. 2; *ibid*., 6 November 1919, p.2; *ibid*., 1 June 1920, p. 3; *The Mercury*, 23 October 1919, p. 12.
[84] *Omeo Standard*, 1 September 1916, p. 2; *The Argus*, 5 October 1916, p. 3; *Bairnsdale Advertiser*, 7 March 1917, p. 2; *North Western Advocate*, 27 March 1917, p. 3.
[85] *Advocate*, 6 July 1921, p. 4: 1.065m diameter pelton wheel fitted with '20 buckets 13in. wide by 9½in. deep'; J. McCutchan & R. Sumner, 'A pioneer hydro-electric scheme', *Proceedings Conference Engineering in the 80's*, Institution of Engineers Australia, Adelaide, April 1980, p. 7: the Cassilis power plant was the 'first significant hydro-electric scheme in Victoria', flanged steel pipe column manufactured by Mephan & Ferguson (Melbourne).
[86] *The Mercury*, 4 September 1917, p. 6; *ibid*., 24 October 1918, p. 2; AB948/1/70, 1 March 1918, *TAHO*.
[87] NS1971/1/310 to 317, designs for the hydro-electric plant and balance tank at the head of the pipe column were prepared at the Melbourne office of consultant engineer George W. Stewart AIEE, *TAHO*; *Examiner*, 13 March 1918, p. 2; *ibid*., 31 May 1919, p. 4.
[88] *Examiner*, 15 October 1919, p. 2; *ibid.,* 28 October 1919, p. 2; *ibid.,* 1 April 1921, p. 2; *Daily Telegraph*, 13 November 1919, p. 2; NS1971/1/326, G. Weymouth Pty Ltd Drawing 1931, 'General arrangement 10 stage turbine pump, 2 sets required Nos. 156-157', with 12,500 gallon per hour capacity under 650ft. head, 7 December 1917, *TAHO*.
[89] *Sydney Morning Herald*, 9 October 1920, p. 13; *ibid*., 11 November 1921, p. 7.
[90] *Examiner*, 24 March 1921, p. 4; *Sydney Morning Herald*, 26 February 1921, p. 14: between 10 November 1920 and 17 February 1921 silver price fell 35% and the lead price 44%; *Daily Telegraph*, 5 August 1921, p. 8: estimated losses of £17-18,000 attributed to the Broken Hill industrial disputes.
[91] *Daily Telegraph*, 21 February 1920, p. 11; *Examiner*, 6 March 1920, p. 7.
[92] M.A. McLeod et al, 'Protective effect of maritime quarantine in South Pacific Jurisdictions: influenza pandemic', *Emerging Infectious Diseases*, vol. 14, no. 3, March 2008, pp. 468-70, reproduced at www.ncbi.nlm.nih.gov/pmc/articles/PMC2570822/
[93] *Examiner*, 4 September 1919, p. 2; *ibid*., 10 September 1919, p. 2; *ibid*., 23 September 1919, p. 2.
[94] 'Official Year Book of Commonwealth of Australia No. 13', *Australian Bureau of Statistics*, 1920, p. 1129: the death rate in Tasmania was one of the lowest recorded worldwide at 1.14 per 1,000 population.
[95] *TPP*, v. 83, no. 5, May 1920, p. 8.
[96] *Daily Telegraph*, 22 March 1921, p. 2; 14 March 1922, p. 2; *Advocate*, 6 July 1921, p. 4; *ibid*., 23 July 1921, p. 5.
[97] *Advocate*, 28 February 1922, p. 4; *ibid*., 7 March 1922, p. 3; *Commonwealth Bureau of Meteorology*, pp. 84 & 86: 50-year mean value for Waratah = 2,184mm.
[98] *Daily Telegraph*, 1 April 1922, p. 2; *ibid*., 6 May 1922, p. 8; N. Ramshaw & D. Palmer, 'A brief history of the Zinc Works in Hobart', *Proceedings 16th Engineering Heritage Australia Conference*, Hobart, November 2011, pp. 2-3: Electrolytic Zinc Co. 10 ton plant commissioned January 1918 and 100 ton plant November 1921.
[99] *Ibid*., 1 June 1922, p. 2; *Geological Survey Bulletin*, no. 33, p. 168.
[100] *Examiner*, 26 September 1922, p. 8; *ibid*., 31 October 1922, p. 3; MIN90/1/6, 10 SH as WR 2228W, 3 November 1922, *TAHO*.
[101] *Examiner*, 10 April 1923, p. 5; *ibid*., 8 May 1923, p. 8; *Commonwealth Bureau of Meteorology*, p. 84.
[102] *Ibid.,* 24 April 1924, p. 3; *ibid*., 1 June 1923, p. 8; *ibid*., 31 July 1923, p. 2.
[103] *Ibid.,* 28 November 1922, p. 2; *ibid*., 18 December 1923, p. 1; *ibid*., 29 January 1924, p. 1.
[104] *Advocate*, 9 December 1924, p. 4; *ibid*., 12 January 1925, p. 7; *The Mercury*, 29 January 1925, p. 4.
[105] *Examiner*, 30 May 1925, p. 2; *ibid*., 29 May 1926, p. 8; *ibid*., 28 May 1927, p. 11: additional pumps for No. 16 Level were purchased during the first half of 1927.
[106] *The Mercury*, 20 January 1908, p. 5; K. Preston, 'Mount Bischoff Tin Mines: Pioneers of water power in the Tasmanian mining industry', *Journal of Australasian Mining History*, v. 8, September 2010, p. 163.
[107] For example in 1923 between 31 Jan - 10 March, in 1926-27 between 15 December - 7 February.
[108] Available water rights by November 1922 amounted to 42 sluice heads (Appendix 2) which equates to 1.725ML per hour; McCutchan & Sumner: water consumption of the Voith pelton wheel at Cassilis was 32.4kL per hour or 0.8 SH equivalent to 0.78ML per day for 24 hour operation of the mine pumps.
[109] Preston, 'Mount Bischoff Tin Mines…', p. 163; *TPP*, v. 97, no, 4, May 1927, p. 25.
[110] *Advocate*, 1 October 1928, p. 4; *Examiner*, 12 July 1929, p. 11.
[111] *Examiner*, 1 June 1923, p. 8; *ibid*., 12 July 1929, p. 11; *Advocate*, 15 July 1929, p. 3.
[112] NS1971/1/371, Magnet S.M. Co., 'Cross section through dam showing proposed extension', 26 July 1929, *TAHO*.
[113] *Chemical Engineering & Mining Review*, v. 21, August 1929, p. 449; *The Argus,* 13 May 1930, p. 4; *The Mercury*, 11 December 1930, p. 5; *Examiner*, 10 April 1931, p. 10.

[114] *TPP*, v. 107, no. 1, May 1932, p. 10; *Advocate*, 4 August 1932, p. 8.
[115] *Advocate*, 11 June 1932, p. 8; *ibid*., 4 August 1933, p. 8; *ibid*., 18 July 1934, p. 8; *TPP*, vol. 113, no. 27, September 1935, p. 26; *Commonwealth Bureau of Meteorology*, p. 86: rainfall for 1933 & 1934 – 17% & 14% below the 50-year mean value respectively.
[116] *Ibid*., 12 November 1935, p. 10; *ibid*., 1 October 1936, p. 8; *ibid*., 15 October 1936, p. 8; *ibid*., 25 November 1936, p. 1; *TPP*, v. 115, no. 5, March 1936, p. 27; 'History of Magnet Mine', UR1891-1969, 22 July 1937, p. 101, *MRT*.
[117] *Ibid*., 13 April 1937, p. 4; *ibid*., 22 May 1937, p. 6; *ibid*., 1 July 1937, p. 8.
[118] *The Argus,* 1 September 1937, p. 10; *ibid*., 4 October 1937, p. 10; *Examiner*, 7 June 1938, p. 8; Barrier Miner 20 June 1927, p. 4: A. Weaver Wincey the mill superintendent at Sulphide Corporation's Central Mine at Broken Hill.
[119] *Advocate*, 4 October 1937, p. 8; *The Argus*, 3 February 1938, p. 8; *Mercury*, 3 November 1938, p. 4.
[120] *Examiner*, 16 March 1938, p. 8; *The Argus*, 1 April 1940, p. 9; *TPP*, v. 123, no. 35, June 1940, p. 28.
[121] *Advocate*, 5 April 1926, p. 10.
[122] K.R. Glasson & R. Cox, 'Magnet Mine, Waratah District', Aberfoyle Partnership, 68-0498, February 1968, *MRT*.
[123] Annual Reports AR1989-90 to 1999-2000, *MRT*: indicate a total Hellyer mine silver with output exceeding 800t.
[124] OS158, June 1900 p. 26, *MRT*; A.H. Blissett, 'Geological Survey Explanatory Report: Zeehan', ER7914S, 1962, p. 194, *MRT*; P.L.F. Collins et al, 'Geological Survey Explanatory Report: Mackintosh', ER8014N, 1981, p. 71, *MRT*.