The Brukunga Pyrite Mine –South Australia A Review of Developments since Closure in 1972

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ABSRACT

The Nairne Pyrite Mine at Brukunga, opened as a source of sulphur for the production of H_2SO_4 to be used in the production of superphosphate fertiliser in 1955 and operated as an open pit until cessation of production in 1972. For two years after closure, two caretakers remained on site until the mining lease expired in 1974. The South Australian Government assumed responsibility for the site in 1977. The open pit is adjacent to and initially drained into the Dawesley Creek, a tributary of the Bremer River, which drains, via the important wine producing area of Langhorne Creek, into Lake Alexandria, at the downstream end of the River Murray. Concerns regarding acid drainage waters entering the surface drainage system including alleged fish kills, led to a continuing programme of attempts to ameliorate the acid drainage impacts. The mine site is covered by an Environmental Protection Authority licence under which a water quality monitoring programme is undertaken with sampling at a number of sites for both water quality parameters and aquatic biology data.

INTRODUCTION

The Brukunga Pyrite mine site is located in the Southern Mount Lofty Ranges, known locally as the Adelaide Hills, some 40 Km east of Adelaide in the state of South Australia. The host rocks are Cambrian calc-siltones (Nairne Pyrite Member) lying within the north-south trending KanmantooTrough, the youngest sequence in the southern part of the Adelaide Geosyncline.

A total of 19 historic mines and mineral prospects occur within the Kanmantoo Trough over a 250 Km long arcuate zone extending from north of Adelaide to Kangaroo Island (Figure 1). The frequent occurrence of mineralised units in the area means that natural production of acidic drainage is common but serious impacts are ameliorated by the generally low rainfall and large depth to the groundwater surface.

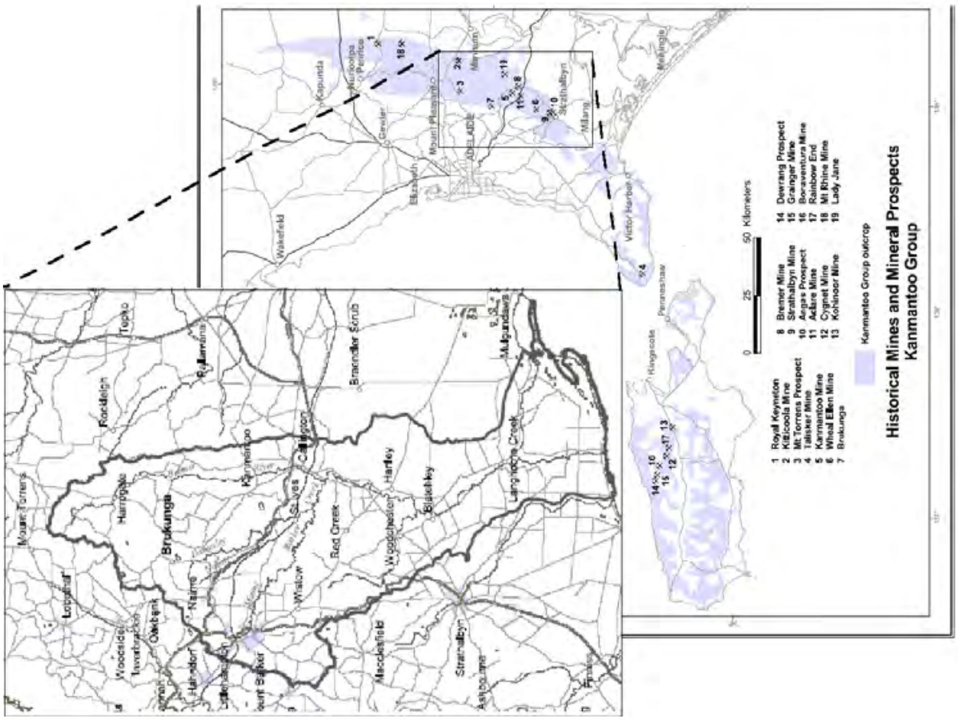

Figure 1 Location of Dawesley Creek Catchment in Kanmantoo Trough

Dawesley Creek rises approximately 5 Km north of Brukunga and flows through the mine site before joining the Nairne Creek some 10 Km to the south. Nairne Creek in turn flows into the Mount Barker Creek 6 Km further to the south, which joins the Bremmer River after a further 3 Km. Some 30 Km to the south, the Bremmer River empties into Lake Alexandria, the artificially maintained lake at the mouth of the Murray River.

The principal land use in the area is grazing, especially in the uplands where the soil cover is very thin and poor although some grain and vegetable growing and viticulture occur in the valleys on alluvial soils especially in the southern area near Langhorne Creek.

Within the surface water catchment, which includes Brukunga, water quality criteria of importance are those related to fitness for consumption by livestock in the upland areas and irrigation of pastures, vegetables and grapes in the valleys.

The climate in the Adelaide Hills is described as Mediterranean with average annual rainfall around 600mm and annual pan evaporation of up to 1500mm. Summers (Dec to Feb) are hot and usually dry and winters are mild with the majority of rain falling between May and November.

BRIEF HISTORY

In the 1950s the world was attempting to rebuild after the end of the Second World War but there were still great uncertainties. Australia was attempting to populate and develop the country. Returned servicemen and assisted immigrants were encouraged to clear land for agriculture. Regular applications of superphosphate fertiliser were needed to sustain cropping in the poor quality soils.

The development of the Brukunga mine was encouraged and sponsored by both the State and Commonwealth Governments to ensure that Australia was self sufficient in supplies of sulphur. The ore mined at Brukunga was a combination of pyrite and pyrrhotite. The minerals were quarried from the side of steep hills adjacent to Dawesley Creek and concentrated at Brukunga before being trucked to Nairne and then railed to Port Adelaide.

The State Government fostered the formation of the mining company, Nairne Pyrites Pty Ltd which was made up of three fertiliser manufacturers and a mine operator; i.e. Cresco Fertilisers; Adelaide Chemical Co; Wallaroo–Mt Lyell Fertilisers; and The BHP Company, who at that time were busy developing their iron ore mines at Whyalla (Eyre Peninsula).

Production commenced in June 1955 and continued for 17 years closing on the 31st May 1972. During its life the mine produced 5.5 million tonnes of iron sulphide ore at approximately 380,000 tonnes per annum. The ore mined had an average grade of 11% sulphur and was milled to produce a concentrate at 40% sulphur. At Port Adelaide the ore was converted to sulphuric acid (H_2SO_4) and was then mixed with imported phosphate ores to produce superphosphate fertiliser for use in South Australia.

The Commonwealth Government paid a bounty to support the mining of pyrite and the manufacture of sulphuric acid through the *Sulphuric Acid Bounty Act, 1954* and the *Pyrites Bounty Act, 1960.* Only two mines were established in Australia specifically to mine pyrite ore, i.e. the Brukunga Mine in SA and the King Mine at Norseman in WA. In the late 1960's a large source of sulphur became available as the result of refining 'sour gas' produced from natural gas fields discovered in Canada. Both pyrite mines ceased May 1972 operations on 31st concurrent with the end of the government's pyrite subsidy.

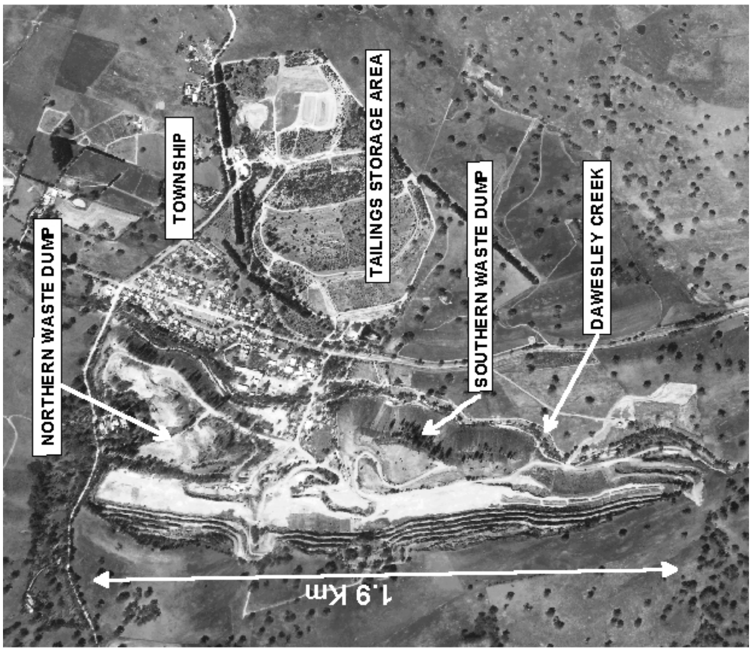

Figure 2 Site Layout – 2001 airphoto

Closure of the mine left a 1,800 metre long open cut quarry bench with two high walls laid back at 43° and 50° and 70 and 85 metres above the quarry floor (Figure 2). Eight million tonnes of waste rock formed the north and south rock dumps. A small rock dump southeast of the mine has been rehabilitated. The sulphide minerals were concentrated by crushing and grinding the ore to fine sand, 80% passing through a 75-μm sieve and floated to achieve separation. The tailings were hydraulically transported by pipeline across Nairne Road to the tailings dam. The once shallow farm valley is now filled with 3.5 million tonnes of sandy-silt stacked 30 metres above the old valley floor at the front edge and covering an area of 28 hectares.

After closure in May 1972, two permanent caretakers were employed to maintain pumps used to transfer acid seepage water collected in the mine area and at the toe of the tailings dam into holding ponds on the tailings dam.

February 1974 - a severe storm resulted in the retention ponds overflowing into Dawesley Creek with impacts extending downstream serving to focus local concerns regarding the long term environmental impacts which could affect water quality and heavy metal content of stream borne sediments as far as Lake Alexandrina.

August 1977 - the South Australian Government accepted responsibility for maintenance/rehabilitation of the site following studies by the Department of Mines and the Australian Mineral Development Laboratories (AMDEL) including in 1976 a re-vegetation trial on the tailings dam. Several bench-sealing trials were carried out using: -

- plastic sheeting covered with 200mm of topsoil
- puddled clay and topsoil
- compacted tailings with and without lime addition
- bitumensed tailings with topsoil

September 1980 – Lime based water treatment plant commissioned by the SA Engineering and Water Supply Department (EWS) to treat water in the holding ponds and the lake of acid water on the tailings dam, which covered an area of 10 Ha, at flow rates of up to 35KL/hr. The backlog of water in the lake was cleared by 1985 after which time only recycled tailings seepage and pit seepage were treated.

1987 to 2000- Tailings Area covered with topsoil and trees planted

1989 – Proposal to use the benches as a livestock feed lot to make use of the animal wastes as biosolids

1993/4 – Face of tailings Dam landscaped and re-vegetated with the help of biosolids from the local sewage water treatment plant. Australian Nuclear and Scientific Technical Organisation (ANSTO) studies based on chemistry and field temperature observations in bore holes estimated that acid generation would continue for between 240 and 750 years under existing conditions.

In May 1995 the Environment Protection Agency (EPA) issued a licence to SA Water (the replacement for EWS) covering the operation and monitoring of activities at Brukunga. The current licence is issued to the Minister responsible for PIRSA who took over the management of the site in 1998 from SA Water.

March 1999 – Brukunga Mine Site Remediation Board (BMSRB) established to advance community consultation and co-ordinate activities at the site.

In 2001 the BMSR Board made recommendations to Government for a $26 million 10-year program of new initiatives. The Government accepted the program and Stage 1 was successfully completed in June 2003 at a cost of $2 million.

Stage I involved the diversion of flow in Dawesley Creek past the mine site to isolate pollution to the site. This was achieved by constructing a drain consisting of 780m of 1.5m diameter concrete pipe, 175m of High Density Polyethylene Plastic pipe and 750m of open channel drilled and blasted though rock. (Figure 3) The section of creek isolated by the drain is now used as a sink to collect acid seepage previously bypassing the seepage collection pumps. The drain has had an immediate improvement on water quality and frogs have been reported croaking in Dawesley Creek downstream of the mine in what was previously polluted water.

In Stage II the capacity of the treatment plant was doubled and the process modified to produce denser gypsum sludge. This work was undertaken in April 2005 enabling the extra drainage created during winter to be treated.

Stage III is to relocate the 8 million tonne rock dumps back into the quarry and import and blend limestone marl at $3 million per annum over 7-years. It is envisaged that acid seepage from the site will diminish significantly on completion of the new initiatives but will still require a site presence to collect seepage from the tailings for treatment and for land management of the 123 ha site.

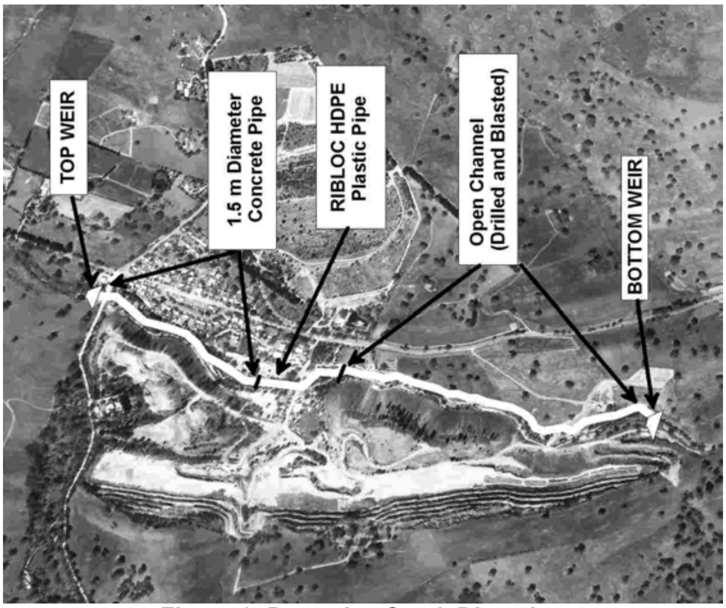

Figure 3 Dawesley Creek Diversion

MONITORING

Monitoring requirements are laid out in an annual Environment Protection Authority site licence first established in 1996 and any remediation work conducted on the site requires an Environmental Improvement Program. The objectives of the water quality monitoring programme as set out in the EPA site license are

1. Determine the annual and seasonal lodes of heavy metals entering Dawesley Creek from the site by measuring the stream flow and the concentration upstream and downstream of the site.
2. Determine the extent of impact of the site (the zone of impact) on Dawesley Creek and the Bremer River by undertaking a biological (macroinvertebrate) monitoring program every three months.
3. Determine the temporal and spatial variations of pH and heavy metal concentrations within the zone of impact by undertaking a monthly sampling program at a selection of fixed sites within the zone for the purpose of assessing compliance with the water quality guidelines for the protection of aquatic ecosystems as given in the Australian Water Quality Guidelines for Fresh and Marine Waters, 1992.

Taylor and Cox (2004) discuss the monitoring in some detail up to early 2004. This paper serves as an update to illustrate the environmental improvements achieved by the latest phase of remediation work focussing specifically on the changes happening in the Dawesley Creek upstream and downstream from the mine site.

DISCUSSION

In the years up to 2003 it is estimated that remedial works and water treatment on site was intercepting only some 50% (600tpa) of the sulphate escaping from the waste rock dumps and quarry floor. Since the completion of the diversion drain and doubling of the lime treatment capacity the interception rate is estimated to be between 90 and 95%. Under the current regime most of the losses are believed to occur during heavy rains when dilution of contaminants leaving the site is at its maximum.

Figure 4 illustrates the effectiveness of the drain in terms of pH and heavy metals using Zn as an example. Activities prior to June 2003 had no apparent impact on either pH or Zn levels with almost 2 orders of magnitude increase in the latter as the creek passed the site. Since June 2003 the downstream pH has returned to around 7.0 and Zn has fallen by approximately a factor of 10.

The highly toxic contaminant Cadmium (Cd) is shown in Figure 5 to have fallen for most of the year below the ANZECC recommended livestock limit of 0.01 mg/L compared with previous years when that limit was exceeded for most of the time. The monthly rainfall pattern is also shown on Figure 5 to confirm that the changes in Cd levels are attributable to the diversion drain rather than a change in rainfall distribution.

The most dramatic change, and the most welcome from the point of view of the environmental lobby, is seen in Figure 6, which shows the Taxon Richness (essentially the number of types of macroinvertebrate present in a sample) determined every 3 months, for the 9 years up to 2004. Since the completion of the diversion drain the downstream levels are beginning to approach those upstream, probable for the first time since the late 1950's (Maxwell and Scott 2004). The numbers for the hot, dry December quarter (Figure 7) show a gradual increase in richness beginning in 1998 with a dramatic step increase in 2003.

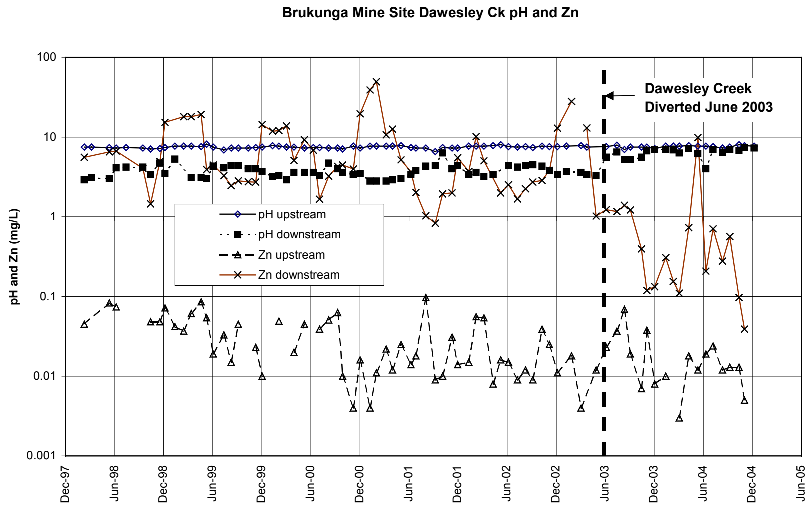

Figure 4 pH and Zn in Dawesley Creek 1998 to 2004

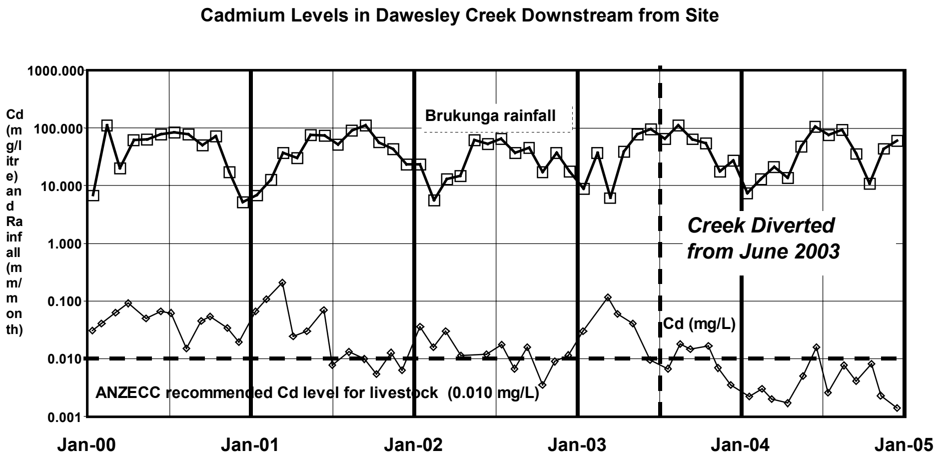

Figure 5 Cadmium in Dawesley Creek and Rainfall 2000 to 2004

The suitability of downstream water for agricultural uses is a community concern and Government is also concerned about the suitability for aquatic ecosystems. Figure 8 shows the monthly values of Cd in Dawesley Creek water downstream from the mine together with ANZECC recommended limits for livestock consumption (0.01 mg/L) and aquatic ecosystems (0.002 mg/L). The livestock limit is exceeded in only one month and for 6 months the Cd levels are close to or less than the aquatic ecosystems limit. Local reports of frogs croaking in the creek downstream of the mine for the first time in living memory provide additional evidence of the much improved environmental conditions.

The annual maintenance budget for Brukunga is $A600, 000. Any new rehabilitation works have to be funded in addition to annual costs. The estimated $A 3million for 7 seven years to relocate 8Mt of waste rock materials, import and blend limestone marl and revegetate will hopefully see the end of major works at Brukunga. The collection and treatment of seepage will continue to be needed but hopefully at a reduced rate.

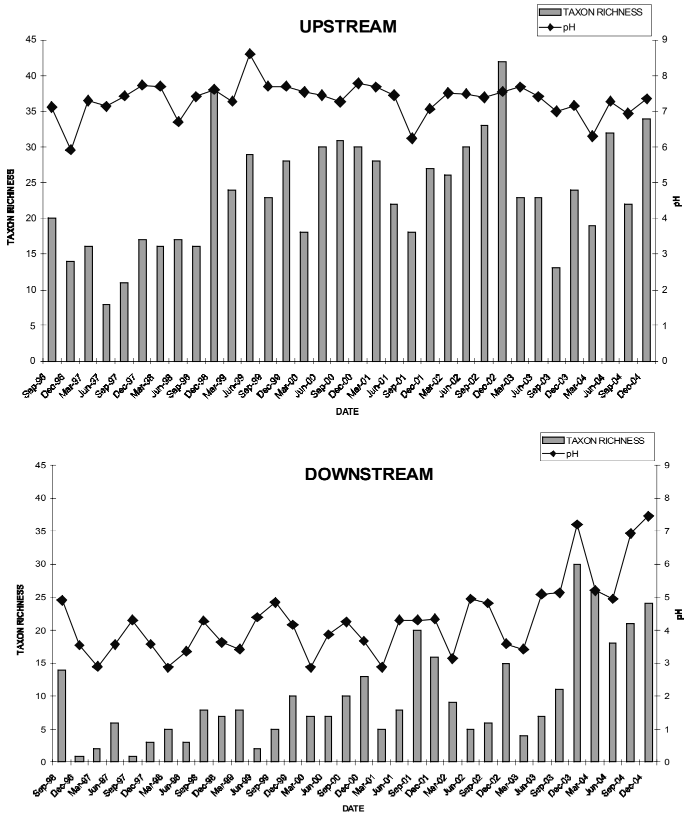

Figure 6 Quarterly Taxonomic Richness upstream and Downstream in Dawesley Creek

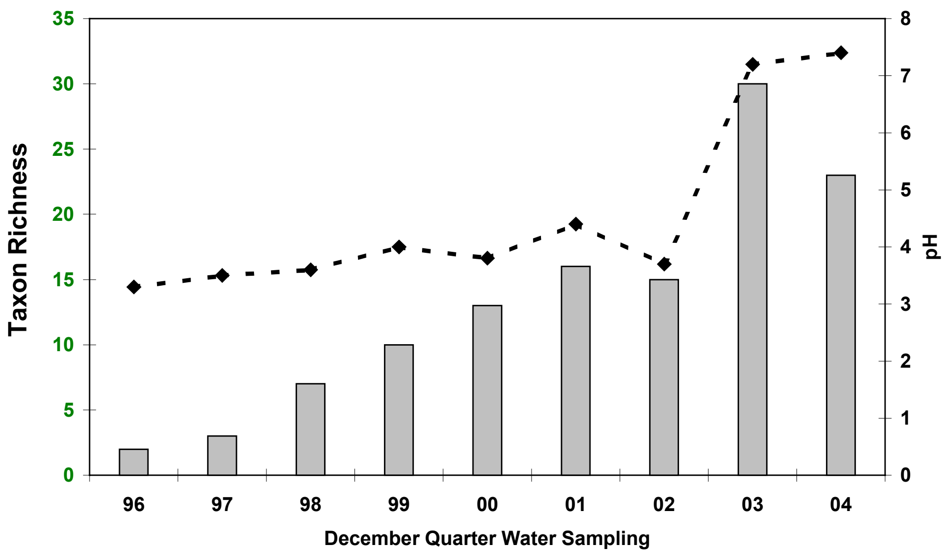

Figure 7 Quarterly count of the macroinvertebrates living in Dawesley Creek water samples

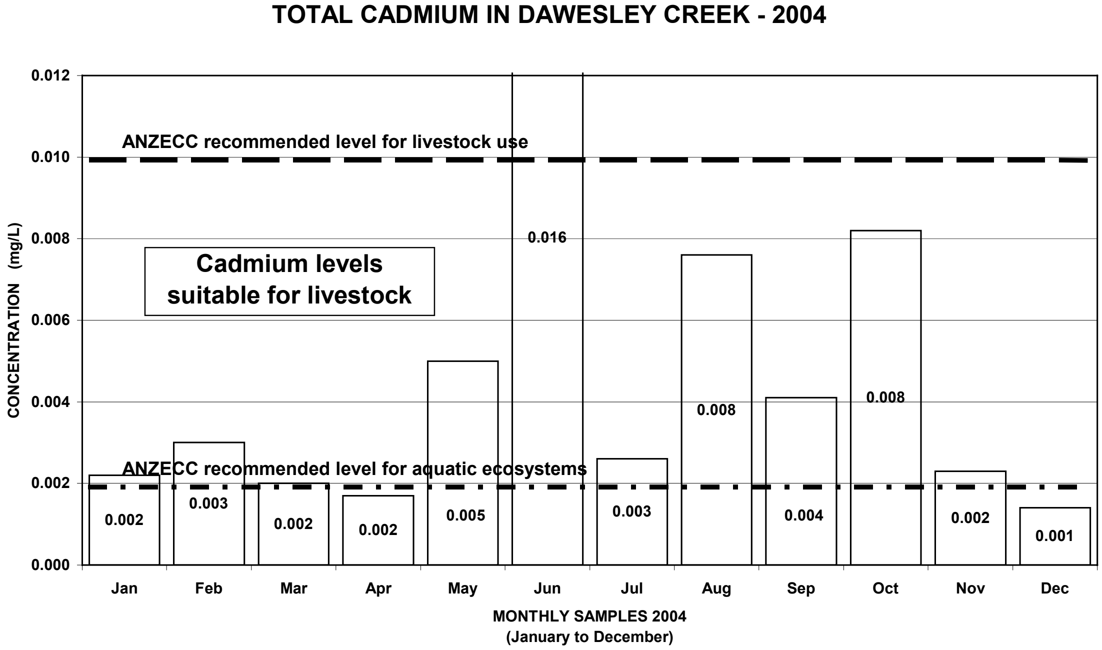

Figure 8 Dawesley Ck. Cd compared with ANZECC "standards"

ACKNOWLEDGEMENTS

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