

# Brukunga Mine Site

## Notes for Visitors

november 2012

### The township of Brukunga

The township of Brukunga is located 5 km north east of Nairne and 40 km east of Adelaide in the Mt Lofty Ranges. The town has approximately 220 people and 72 houses, now almost all privately owned. It was built in 1952 by the Government housing trust for rent to the Mine employees.

### Site management

The South Australian Government took responsibility for the site in 1977. The former Engineering and Water Supply Department (later SA Water) operated the Brukunga site from 1980 to 1997. In 1998 operational responsibilities transferred to the Department of Primary Industries and Resources South Australia (PIRSA) and is presently with the Resources and Energy Group of the Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE).

Two dedicated full-time staff manage the treatment plant and maintain the mine property. A range of short-term contractors are used for specialty tasks including electrical, vehicle maintenance and plant, preventative and breakdown maintenance.

Technical management for budgets, planning, projects, water monitoring and reporting to the Environment Protection Authority (EPA) is provided from DMITRE Adelaide office based staff.

The annual budget for site operations is in the order of \$750,000 per annum. The property has an area of 123 hectares and requires continuing maintenance of fences, firebreaks, noxious weeds and other pests, roads, stormwater drains, landscaping and tree planting.

### Historic setting for Brukunga

The historic Brukunga Mine was established in the 1950s as a source of sulphur to be converted to sulphuric acid for use in the manufacture of superphosphate fertiliser. Australian soils tend to be of a poor quality requiring applications of fertiliser to sustain cultivated crops.

When the Mine was constructed in the 1950s the world was rebuilding after World War II and there was a great shortage of all materials.



# Notes for Visitors

## Brukunga Mine Site

2012  
november

Australia realised it was isolated from the UK and it became policy to become self-sufficient, increase the population and develop regional areas. Assistance was offered to pay for immigrants to come to Australia to clear and develop the land and increase agricultural production.

### Mining at Brukungu

The development of Brukungu Mine was encouraged and sponsored by both the State and Commonwealth Governments as part of the drive for self-sufficiency and full employment. The State Government fostered the formation of the company, Nairne Pyrites Pty Ltd, a consortium of three fertiliser manufacturers and a mine operator: Cresco Fertilisers, Adelaide Chemical Co, Wallaroo – Mt Lyell Fertilisers and The BHP Company, who were also busy developing their Whyalla iron ore mines.

The Mine commenced production in June 1955 and continued for 17 years, closing on 31 May 1972. The Mine produced 5.5 million tonnes of iron sulphide ore at ~380,000 tonnes per annum. The ore had an average grade of 11% sulphur that was crushed and concentrated onsite to 40% sulphur. The pyrite ore lode is a mix of two iron-sulphide minerals, these being pyrite ( $\text{FeS}_2$ ) & pyrrhotite ( $\text{FeS}$ ).

The minerals were quarried from the side of two steep hills using a power shovel and trucks. The mine concentrate was trucked to a rail siding at Nairne and then railed to Snowdens Beach, Port Adelaide where it was converted to sulphuric acid ( $\text{H}_2\text{SO}_4$ ). Imported phosphate rock was treated with the acid to produce superphosphate fertiliser to sustain South Australian agriculture.

To encourage mining of pyrite for production of sulphuric acid the Commonwealth paid a bounty via the *Sulphuric Acid Bounty Act, 1954* and the *Pyrites Bounty Act, 1960*. Only two mines were established in Australia specifically to mine pyrite ore, these being Brukungu and the King Mine at Norseman, Western Australia. In the late 1960s cheaper sources of sulphur became available mainly due to Canada's refining of 'sour natural gas'. The government withdrew the pyrite subsidy on 31 May 1972 and both pyrite mines ceased mining operations on the same day.

### After mine closure

Following mine closure the crushers and metallurgical plant were dismantled and the mine office and workshops later became the start of the Country Fire Service (CFS) State Training Headquarters, which still operates to this day. The quarry bench is 1.8 km long with two high walls 70 m and 85 m laid back at 45° and 50°. The 8 Million tonnes (Mt) of rock removed to access the pyrite was discarded to form the north and south waste rock dumps. A small south east waste rock dump was remediated in the 1990's.

Concentration of the sulphide ore by crushing and grinding to a fine sand, 80% passing a 75 mm sieve, produced 3.5Mt of mill tailings that was pumped to the other side of Pyrites Road to fill a shallow farm valley to create a Tailings Storage Facility (TSF). The tailings at the front edge is 30 m above the valley floor and covers an area of 28 hectares.

# Notes for Visitors

## Brukunga Mine Site

2012  
november

### Environmental concerns

The main environmental concern at Brukunga is caused by the natural oxidation of pyrite minerals in air and water to form sulphuric acid, known as Acid and Metalliferous Drainage (AMD). The small amount of pyrite still remaining in the waste rock dumps and the tailings dam causes AMD to seep out at base of the dumps. The acid waters also dissolve small amounts of other metals from the minerals.

Dawesley Creek flows north to south through the Mine site and picks up contaminants, carrying them downstream into Mount Barker Creek, Bremer River and into Lake Alexandrina. Soon after the mine opened and up to a construction bypass of the creek in 2003 the water from the Mine was so contaminated with sulphate and heavy metals such as aluminium, iron, cadmium, and manganese. The water was unsuitable for livestock and irrigation use up to 55 km downstream of the Mine site.

The geological formation hosting the pyrite is not specific to Brukunga and extends 40 km north and south of the Mine and



Acid and metalliferous drainage contaminating Dawesley Creek at Brukunga Mine

also continues steeply into the ground beneath the current quarry floor. The blasting and crushing activity of mining increased the surface area of the pyrite exposed to the air, significantly increasing the amount of oxidation occurring. This is an order of magnitude greater than that occurring naturally when the minerals were in the ground.

In 1993-94 Australian Nuclear Scientific and Technology Organisation (ANSTO) were engaged to provide an estimate of how long the oxidation would continue above previous background levels. Temperature and oxygen levels were monitored in a series of boreholes drilled into the tailings and rock dumps and the results were used in calculations which indicate that the reactions are likely to continue for 240 years and up to 750 years. Subsequent analysis indicates that this figure could potentially be in excess of 1,000 years.

In March 1999 the *Brukunga Mine Site Remediation Board* (BMSRB) was formed to replace the technical based *Brukunga Taskforce*, placing emphasis on local community involvement in developing new management solutions to the problem. The BMSRB advise the Minister on strategies for environmental improvement and is made up of representatives from the Dawesley Creek Catchment Landcare Group, the District Council of Mount Barker, the community and DMITRE.

### Seepage interception

During mining much of the acid water was controlled by reusing it in the metallurgical plant. After closure in 1972 Nairne Pyrites Pty Ltd employed two caretakers to collect and pump contaminated water to a large

# Notes for Visitors

## Brukungu Mine Site

2012

november

evaporation lake on the tailings dam. In February 1974 a summer storm caused the lake to overflow and it was soon realised that the water would not naturally evaporate. The Department of Mines and Australian Mineral Development Laboratories (AMDEL) began to investigate the issues. In August 1977 the State Government accepted responsibility for management and remediation of the site.

In September 1980 the Government commissioned the acid neutralisation plant to treat the acid water. The Department of Engineering and Water Supply (E&WS) were appointed the operators and within 5 years of treatment the 10 ha lake of acid water was removed from the tailings dam. Contaminated water percolating through the tailings dam and from the mine waste rock dumps and benches was then collected by 12 pumps spread about the mine site and treated by the plant. Acid water is collected from the quarry bench, the waste rock dumps and from the section of creek bed isolated by the diversion drain. The collected water is held in two ponds located at the base of the tailings dam. Polluted water from the holding ponds is pumped to the plant by a range of 6 parallel-mounted varying capacity screw-pumps. The feed rate to the plant (from 15kL/hr to a peak rate of 63kL/hr) is achieved by operating a selected pump or group of pumps.

Treatment requirements are greatly influenced by seasonal and local rainfall. During the dry summer the plant is often shut down for several weeks at a time, which allows for essential maintenance. During the wet winter months (June to September) the plant is operated 24 hours/day and 7 days/week at rates varying

from 20 to 40kL/hr. During persistent wet periods the plant operates at a peak feed of 63kL/hr for several days or more, as necessary to prevent the holding ponds overflowing.

Despite all the work done from 1980 to 2003 to intercept and treat acid drainage only about half the contaminated water from the site was captured and treated, the remaining 50% or ~600 tonnes per annum of sulphate escaped to Dawesley Creek. On completion of the diversion drain in June 2003 it became possible to intercept much more of the contaminated water, with most of the loss occurring during high rainfall events, when there is greatest dilution helping to produce lower concentrations in the stream.

### Neutralisation treatment plant

The inputs to the plant are hydrated lime and carbide lime ( $\text{Ca}(\text{OH})_2$ ), at pH 12, dilute sulphuric acid waters ( $\text{H}_2\text{SO}_4$ ) at pH 2.3 and oxygen ( $\text{O}_2$ ) provided by air blowers to ensure the chemical reactions are complete before the mix leaves the plant. The outputs are gypsum precipitate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and water ( $\text{H}_2\text{O}$ ), which are physically separated in the thickener (large dewatering tank). The precipitate sinks to the bottom and is drawn from underneath by variable speed hose-pumps. The water overflows into the trough around the top of the tank. The overflow water is clarified in a large concrete lined pond, providing time for residual particles to settle before the water is returned to the creek via an open channel. The plant process schematic is provided in the following diagram.

# Notes for Visitors

## Brukunga Mine Site

2012

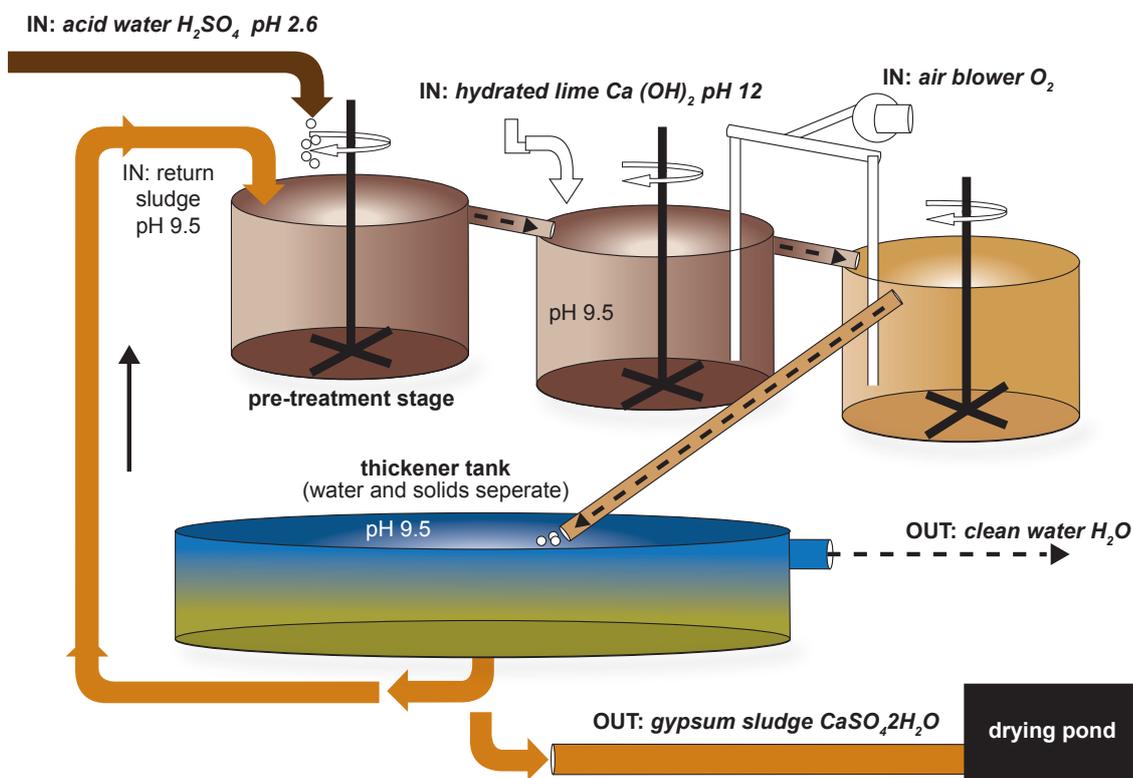
november

The process of lime neutralisation occurs in a series of three mixing tanks providing retention time for completion of the chemical reactions. In May 2005 a second parallel series of three larger tanks were installed to effectively double the treatment capacity of the plant.

For many years the main source of lime used in the plant was an industrial waste product from the manufacture of acetylene gas using calcium carbide (known as carbide lime). Annual consumption was variable at approximately 600 dry tonnes per annum. Hydrated lime was used as a supplementary source of lime during winter, when there are higher flows of water requiring treatment.

Manufacture of acetylene gas ceased in South Australia in September 2008 and Brukunga lost its main source of lime for the treatment process. Hydrated lime was used exclusively between 2008 and 2011, however in 2012 a new source of carbide lime became available. The plant currently uses a blend of carbide and hydrated lime as required.

The plant process is pH controlled. Dissolved heavy metals come out of solution over differing pH ranges. As the pH is raised in the plant the metals attach themselves to the gypsum particles. A variable-speed hose-pump is used to adjust the lime feed to maintain the pH in the thickener tank at pH 9 to 9.5 to ensure the removal of cadmium and manganese from solution.



The neutralisation process occurs in a series of 3 mixing tanks, which provides sufficient retention time for completion of the chemical reactions.

# Notes for Visitors

## Brukungu Mine Site

2012

november

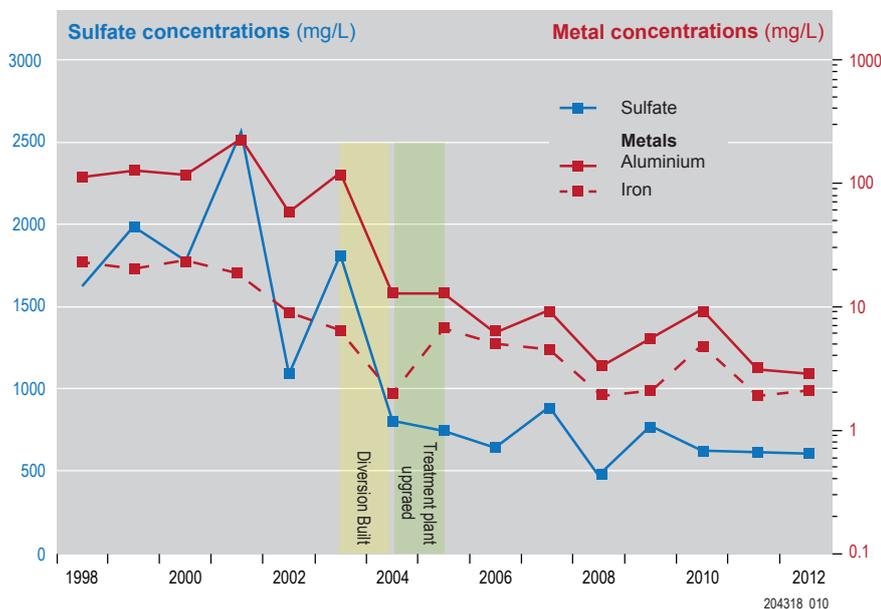
Because the pH is maintained high, excess hydroxide ions attach to the gypsum particles produced in the plant. Pre-treatment of the raw acid water feed (pH 2.3) is achieved by returning high volumes of the alkaline plant sludge (pH 9.5) into the first mixing tank. This raises the pH of the mix to pH 7.5 before any new lime is added. The new lime is added into the second mixing tank and both the second and third tanks are aerated. An advanced polymer flocculant is added to the thickener tank to assist in the settling of fine particles.

The gypsum sludge produced in the plant is recirculated for the pre-treatment of the raw acid feed for 5 or 6 days until a sludge density in the thickener tank of 25 to 30% weight solids is achieved, determined empirically by the torque load indicated on the thickener rake. A batch of sludge is then drawn off for about 6 hrs and pumped to the drying impoundments. The impoundments are located at the back of the tailings dam and need to be excavated each summer to provide the void for holding the following

year's production. The dried gypsum is stockpiled in the mine site. New above ground impoundments replaced the sludge ponds in 2007 and 2008, reducing the percolation of water from the sludge into the tailings dam.

### New government initiatives

In 2001 after considering various studies the BMSRB recommended a \$26M program of new initiatives to the Minister and Government. The Government approved the program and Stage 1 - the diversion of Dawesley Creek past the Mine was successfully completed in June 2003. The drain isolates contaminated water at the Mine site. The 1.7 km diversion included 780 m of 1.5 m diameter pipes, 175 m plastic pipe and 750 m of drilled and blasted open channel. The isolated section of creek now provides a sink for the collection of acid seepage that previously evaded the system and was released into Dawesley Creek



Concentrations of sulfate and metals downstream of Brukungu Mine. Water quality has improved since 2003 (as indicated by decreasing concentrations of sulfate and metals) following diversion of part of Dawesley Creek around the mine.

# Notes for Visitors

## Brukunga Mine Site

2012

november

The second stage of the new initiatives - a doubling of the peak acid treatment capacity, was completed in May 2005 at a cost of \$0.75M.

Construction of the drain and the upgrade of the treatment plant resulted in an immediate improvement in water quality. Frog croaking was heard in Dawesley Creek downstream of the Mine for the first time in 50 years.

### **‘Store-and-release’ tailings dam vegetation cover**

The planting of vegetation on the tailings dam commenced with trials in 1987 after a thin layer of 30 to 50cm of soil and rubble was spread on the tailings. Several thousand natives species of plants have been planted over the tailings area from tube-stock. The established vegetation reduces surface erosion, improves the visual appearance and provides habitat, but also forms an evapo-transpiration layer to reduce the deep percolation of rain into the tailing sand. Moisture is temporarily held in the root zone of the plants and from there it evaporates or is drawn up into the biomass of the vegetation, or transpires from the leaves. This reduced deep water percolation minimises the quantity of acid seeping from the toe of the tailings dam. Monthly measurements of depth to ground water in boreholes indicate that each year the tailings are drying internally. This is also confirmed by decreasing quantities of seepage from the toe, measured continuously by a crump gauging weir.

A great deal of the successful establishment of the vegetation was due to the use of ‘biosolids’ from the annual clean

out of Waste Water Treatment Plants or from regular daily truckloads of wet septic sludge cleared from local hills domestic septic tanks. The biosolids were spread thinly on the surface and contributed by increasing soil cover, providing moisture, nutrients, organic matter and the bacteria necessary to invigorate healthy plant growth.

### **Brukunga mine remediation program**

A whole of site remediation strategy is currently being developed to reassess the proposed third stage of the program.

The South Australian Government’s overall remediation objectives for Brukunga include substantially limiting or avoiding the need to intercept and treat acid waters indefinitely; returning all or part of the site back to productive use(s) or for environmental / ecosystem values; and applying leading practice to site management and remediation options.

A Technical Advisory Group (TAG) was formed in mid-2007 to assist DMITRE to determine the most effective long-term remediation solution for Brukunga. An independent body – the former Australian Centre for Minerals Extension and Research (ACMER) assisted DMITRE in selecting Group members.

The role of the TAG is “to provide independent assessment, opinions and recommendations to design a cost effective final solution that meets the overall project objectives”.

In 2012 the TAG comprises of nine members consisting of geochemical, hydrogeological, geotechnical and geomorphological experts.

# Notes for Visitors

## Brukunga Mine Site

2012

november

The TAG is following a series of agreed phases to complete the project. They have investigated and assessed potential remediation options for the Brukunga mine and have determined that the preferred remediation option is technically and scientifically feasible.

In 2012 DMITRE divided the mine site into 'domains' and is currently in the final investigation and design phase for the Days Creek domain remediation. Once completed, this will reduce the amount of AMD generated by the waste rock dumps, tailings dam and mine benches.

The remediation design involves the placement and compaction of waste rock and tailings, blended with limestone, behind a constructed seepage cut-off. This will allow the groundwater level to saturate the mine wastes, greatly reducing the ingress of oxygen and limiting the production of AMD. To maintain groundwater saturation a cover system will be constructed over the mine waste that will both allow infiltration and limit evaporation of the groundwater. The creek system that flows through the mine site will be re-diverted over the cover system to avoid contact with any AMD producing waste.

The Days Creek domain remediation will involve placement of approximately 800,000 m<sup>3</sup> of the 12 million tonnes of waste rock and tailings into two mine voids in the mine bench. The northern portion of the mine bench will be covered and eventually returned to a post-mine land use.

## Water monitoring programs

The *Environment Protection Act 1993* requires a licence for the Brukunga Mine site. The licence requires the watercourse to be monitored using three different approaches:

- Monthly chemical grab sampling for seasonal and spatial variation to the Bremer River;
- Load calculation using continuous flow records and analysis of composite water samples; and
- Quarterly biological sampling for macroinvertebrates to assess taxon richness.

Samples are analysed by water quality laboratories for sulphate (SO<sub>4</sub>), pH, electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), iron (Fe), aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), zinc (Zn), lead (Pb), manganese (Mn) and nickel (Ni).

To determine pollution load (i.e. the mass of contaminant transported from the Mine site) continuous logging of the flow of Dawesley Creek at two concrete v-notch weirs located above and below the mine site is required. In addition, automatic sampling pumps place water samples into a holding bucket at intervals proportional to the flow rate of the stream. A composite sample from the bucket is analysed fortnightly and the bucket reset. The load is the product of flow volume and chemical concentration. The results of water monitoring are prepared as an annual report presented to the EPA.

**Visit our web site for photos, articles and other technical reports.**

**[www.minerals.pir.sa.gov.au/brukunga](http://www.minerals.pir.sa.gov.au/brukunga)**

# Notes for Visitors

Brukung Mine Site

2012

november

