A Strategic Overview of Acid Rock Management and Remediation at Savage River

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ABSTRACT

An innovative partnership, the Savage River Rehabilitation Project (SRRP), between the Tasmanian Government and Grange Resources (Tasmania) Limited, has led to the remediation of the Savage River in North Western Tasmania. Prior to the Savage River Mine initially closing in 1996, the Savage River was biologically dead for 30 kms downstream due to the impacts of acid rock drainage and high sediment loads. Following the development and implementation of the Goldamere Act, which provided indemnities against past pollution, Goldamere Pty Ltd, now Grange Resources (Tasmania) Limited, purchased the operation from the Tasmanian Government in 1996 and commenced mining in November 1997.

The SRRP is funded by both Grange Resources (Tasmania) Limited (Grange) under a purchase price agreement which allows Grange to undertake remediation contracts for the Crown (Tasmanian Government) to “work off” the $AUD13M purchase price initially owed by Grange to the Crown; and by the Government through use of $AUD11.4M paid by the previous mine owners to walk away from the site.

As a result of this innovative partnership the Tasmanian Government has been able to achieve significant remediation at minimal cost. For their part, Grange has developed effective and innovative ARD management strategies to remediate the legacy found at this site. The Savage River Remediation Project has resulted in the re-opening of an old mine, provided long-term employment to several hundred Tasmanians, injected in excess of $100M annually into the Tasmanian economy and has led to the formation of a long-term mutually beneficial relationship between a mining company and an Environmental Protection Authority.

Additional Key Words: legacy pollution, strategic planning.

INTRODUCTION

Savage River was established by Pickand Mather Incorporated (PMI) with an open cut mine, concentrator and a concentrate pipeline to a pelletising plant at Port Latta on the northwest coast of Tasmania. Open cut mining commenced in 1967. Ore production continued until April 1996, when all mining ceased. PMI then returned the mine to the Tasmanian Government along with a remediation fund of $ AUD 11.4M at the end of their operations.

The operation was sold in December 1996 to Goldamere Pty Ltd conditional on the purchase price to be used for remediation. Goldamere merged with Grange Resources Limited (Grange) in January 2009 to form the largest magnetite producer in Australia.

By the end of 1996, the two streams which traverse the mining lease, the Savage River and Main Creek were adversely impacted by mining. Acid Rock Drainage (ARD) was considered to be one of the main water quality issues at Savage River. Waste rock dumps containing material from the southern pits, particularly the Centre Pit South, were considered most prone to acid leaching. Cu and Ni both exceeded the ANZECC (1992) guideline value for soft waters downstream from the mine site. Koehnken (1992) identified median Cu concentration 25 times over the ANZECC (1992) recommended value for soft waters and maximum Cu concentrations 3-5 times higher than the median concentrations. Davies (1995) suggested that these high Cu concentrations were a major reason for the degraded aquatic ecosystem downstream of the mine.

Following PMI’s closure, the Tasmanian Government commissioned a site assessment (Woodward Clyde, 1996). They estimated that a 20-year operating cost to collect and treat ARD on site could be as high as $AUD 120M (at a 95% confidence level and 1996 dollars). Site experience and further studies (Ray, 2001 and Koehnken, 2007) have shown that this assessment covered less than 50% of the site’s copper load. To put this into context, over a 30- year mine life, the operation generated a liability of $AUD8M per year. On this basis, if Grange manages waste rock and tailings to prevent the oxidation of pyrite, the Grange saves $8M per annum. If Grange can also remediate legacy ARD which under the Goldamere Act is owned by the Crown, a further $8M per annum is saved by the Crown.

As an alternative to standard regulatory approaches, where the mine owner/operator is totally responsible for environmental solutions, the Tasmanian Government and Goldamere negotiated a unique agreement whereby the Crown was responsible for ‘past pollution’ while Goldamere was only responsible for the environmental impacts from its operations. This was legislated in the Goldamere Act which indemnifies Grange in respect to past pollution. This has allowed Grange to remediate the Savage River Mine in conjunction with the Tasmanian Government while re-opening a mine and providing significant benefits to Tasmania through economic, employment and training in addition to the environmental benefits.

SAVAGE RIVER REHABILITATION PROJECT

The Tasmanian Government and Grange developed and implemented a co-operative management and remediation plan, which allows for both parties to benefit. Under the Goldamere Act and the Goldamere Agreement, a management committee with representatives from the Tasmanian Department of Environment, Parks, Heritage and the Arts (DEPHA), Mineral Resources Tasmania and Grange jointly oversee the Savage River Rehabilitation Project (SRRP). This Management Committee recommends action to Tasmania’s Environment Protection Authority (EPA) and is governed by the legal and administrative structures in the Goldamere Agreement.

Project objectives

The SRRP has clear objectives as summarised below:

- to promote recovery of a modified but healthy ecosystem in the Savage River downstream of the mine, and allow fish migration into the upper Savage River.
- to develop and implement a long-term strategic plan for the rehabilitation and remediation of historical disturbances at the Savage River Mine and Port Latta plant.
to integrate remediation projects with ongoing mining operations wherever practical and to co-operate with GRANGE during the planning and implementation of projects.

- to demonstrate best practices in all aspects of the project and to communicate progress and findings to the community.

**Legal structure**

The Goldamere Agreement allows Grange to undertake remediation contracts for the Crown to ‘work off’ the purchase price owed by Grange to the Crown. The Goldamere Act provides Grange with indemnity against pollution caused by previous operations, both existing and that which may occur from previous operations in the future. An essential part of this arrangement is an admission by the Tasmanian Government that:

- ARD from the previous operations may continue for many years
- that Grange is not responsible for this pollution
- co-treatment of pollution may be possible
- emission limits are not appropriate for this situation.

This legislation has allowed Grange and DEPHA to co-operatively manage the remediation process in conjunction with Grange’s mining operation to maximize the benefits for both parties. These benefits include:

- maximizing cost-effective remediation of past pollution
- sharing knowledge regarding remediation
- increasing knowledge of both DEPHA and Grange regarding remediation of ARD and pollution from old mining operations
- co-operative rehabilitation and remediation of the Savage River Mine.

As a result of this, Grange does not operate to licensed discharges but instead has to demonstrate to DEPHA that it is operating to Best Practice Environmental Management each year.

**Administrative structure**

The Goldamere Agreement recognizes that Grange has mining equipment and expertise on site and as a result has a competitive advantage when it comes to using heavy earthmoving equipment for contract work. Consequently the agreement provides a structure that allows contracts to be awarded to Grange, while still ensuring that the Crown is getting value for its remediation dollar and maintaining transparency while spending public money. The framework allows for:

- development of an annual program by the Director of the Environment Protection Authority
- Grange chooses whether it wishes to undertake any individual contracts within the annual program
- where Grange chooses to undertake projects, a proposal is submitted to the SRRP for consideration
• providing the contract price meets the environmental values as developed by the SRRP, the Grange proposal is assessed by an independent contractor to ensure the Crown is getting good value

• if the independent contractor develops a lower price than that proposed by Grange, the lower price is offered to Grange

• if Grange chooses not to undertake the project at the lower price, the contract is put to tender, at which time Grange has the opportunity to resubmit another proposal.

The agreement and legislated indemnity means that Grange can actively configure its mine and waste planning activities to maximize remediation benefits without fear of future litigation for past mistakes. This has resulted in the development of a medium and long term strategies to remediate the Savage River including water management works to reduce sediment loads (turbidity) and increase alkalinity. Grange’s increasingly intimate environmental and engineering knowledge of the site enhances remediation solutions while providing direct employment to over 400 people and over $AUD 100M per annum being injected into the Tasmanian economy.

REMEDIATION STRATEGY
The main emphasis of the remediation strategy is to improve the aquatic ecology in the Savage River. In order to do this, the key methodology has been minimization of ARD flows allowing cost effective long-term treatment. Capping using alkali material has also been used for mitigation.

Minimizing the ARD flows before treatment is achieved by either capping legacy waste rock dumps or by diverting clean water from ARD sources. ARD flow minimization is beneficial because pollution and hydraulic loads are more consistent over time, which reduces the cost of long-term pumping and therefore treatment.

Capping of waste rock alone is not considered by the management committee to be a viable pollution mitigation strategy because the size and location of the legacy dumps means that capping would be prohibitively expensive, if not impossible, using conventional capping technology.

In addition to ARD mitigation, the SRRP has been developing a treatment system for the neutralisation of the ARD that will remain following mitigation. The mixing of ARD with crushed carbonate in an axial flow mixer has been found to be an effective method of neutralisation at the site. This offers large potential cost savings over calcined reagents. The sludge produced by the process has characteristics favorable for disposal, including residual alkalinity. While recognizing that metal hydroxide sludges will need to be stored securely in a circum neutral environment, the SRRP is developing the system and plans to have it fully operational for when the mine is ultimately closed.

The Strategic Plan
The strategic plan was developed to meet the objectives of the Savage River Rehabilitation Project and improve water quality to environmental targets. The strategic plan is to be implemented over the next 17 years to coincide with the expected life of the Grange mine. It focuses on developing long-term solutions for mitigating historic pollution by passive methods and by water treatment. The plan sets the directions for the remediation strategy and specifies how and when each problem will be resolved. It recommends methods for remediating each
source of pollution and provides spreadsheets to estimate the costs and timing for each remediation project. The plan also allows for flexibility in dealing with different remediation options.

**ARD Management**
The keys to effective ARD management at Savage River have been developing a knowledge base of ARD sources, understanding the local geology and the availability of natural materials on site as well as the ecotoxicology of ARD pollutants in the ecosystem.

The natural advantages of steep terrain, wet climate and alkaline rocks in Grange’s waste products have been used to good effect. The steep terrain and high rainfall at Savage River have been used to percolate fresh water through constructed alkaline drains using to generate alkalinity for ARD neutralization, steep terrain to gravity flow ARD to neutralization pits and alkaline waste rocks and silty clays used to encapsulate potential acid forming rock in wet clay blankets

**ARD Sources**
Grange and the SRRP have been identifying and quantifying sources of ARD on site since 1997. This has involved the identification of pollutant loads at gauging stations along the lease, calculating flux balances and then filling in the gaps using campaign monitoring.

Understanding the relative contributions from each source has allowed the prioritization of remediation works.

**Materials Management**
Reviewing and digitizing historical waste rock dump construction, and measuring material permeabilities roads has enabled Grange to plot ARD flow paths, intercept ARD seeps in some areas, and configure remediation activities in conjunction with mining plans. The selective use of alkaline rocks to provide external covers systems and in clean water drains has provided long-term passive treatment systems around the site. Alkaline water entrained in Grange’s tailings is also used for the neutralisation of ARD, and will continue to do so for another 20 years with the planned construction of a new tailings storage facility, the South Deposit Tailings Dam.

**Remediation Works**
The sources of pollution that will be mitigated and treated by the planned SRRP works are shown in Figure 1 below:

- ‘the B-Dump Complex’, the source of approximately 40% of the site’s copper load
- ‘North Dump Drain’, the source of approximately 15% of the site’s copper load
- ‘Crusher Gully’, the source of approximately 10% of the site’s copper load
- The Old Tailings Dam Seeps, currently treated by the Grange tailings in the Main Creek Tailings Dam and responsible for approximately 50% of the acidity generated on the site
- ‘Centre Pit South,’ currently being treated in the central pits by combining with the stormwater from the mine lease.
- Co-treatment of ARD by the tailings to be stored in the planned South Deposit Tailings Dam which will provide a long-term passive neutralisation system to Main Creek.
• Treatment sludges from the South Deposit Tailings Dam treatment will be encapsulated with tailings deposition. After mine closure these will be actively treated and stored in a circum-neutral disused pit.

![Site Layout Savage River](image)

**Figure 1.** Site Layout Savage River.

**Environmental targets for water quality**

The SRRP’s Savage River water quality targets are based on toxicological tests conducted on fish, invertebrates and algae. The tests used waters from the ARD impacted waters from the West Queen River and Savage Rivers. Davies et al (2001) and Davies (2001) showed that Savage River waters are likely to be non-toxic when the pH of the river is greater than 7 and predominately non-toxic with pH from 5.5 to 6.5. The studies also showed that a complex relationship existed between toxicity, Ca and dissolved Cu. Consequently intermediate environmental targets were specified for the lower Savage River and the Savage River immediately downstream of the mine based on the requirements of native and exotic fish.

The project aims for further improvements to protect the more sensitive macro-invertebrate species such as Ceriodaphnia. Toxicological tests for Ceriodaphnia suggest that this species could reproduce successfully if a two-thirds reduction in metal loads in the Savage River were combined with the increase in river alkalinity resulting from the water treatment on the site.
Consequently, the project aims to reduce the total copper load entering the Savage River by at least 65%. This will significantly improve invertebrate health within the Savage River and will also provide a three-fold safety margin for the toxicity targets derived for fish.

Peer review process
An independent review of the SRRP strategic directions is carried out approximately every three years. The review performance against water quality targets and reviews the efficacy of works completed. It also considers planned works and recommends a strategic path forward.

BENEFITS OF COOPERATIVE SRRP PROGRAM

Environmental Performance
Water quality data collected between 1998 and 2000 showed that some 20% of the water samples exceeded the toxicity threshold for fish. However, since 2001 all targets for water quality, including dissolved copper, aluminium and sulfate, have been achieved, with no water samples exceeding the fish toxicity thresholds (Hughes et al, 2009). These results demonstrate a significant improvement in the management of pollution from the mine site, and results since 2005 have demonstrated that the SRRP is achieving ongoing improvements with the river conditions.

Recent studies of the Savage River biota have shown a significant, but partial recovery that is associated with the improved water quality conditions (Davies et al., 2008).

Ownership
Grange’s efforts to remediate the legacy pollution on site and to manage ARD from its own operations have paid a significant dividend at due diligence time. The ability to demonstrate that environmental management is an asset instead of a liability has helped facilitate two consecutive sales of the company in the past five years. Over the ten year lifespan of the business, the reduced risk to investors and equity partners, from effective ARD management practices has shone through in too many due diligences to count. Grange has also benefited from its positive environmental record when hiring and retaining staff.

Relationships
Grange has gone beyond the mandate to comply with legislation. Grange has embraced both the requirement to meet Best Practice Environmental Management and the opportunity it provides to develop a close working relationship with the Crown and other stakeholders.

CONCLUSION
The Goldamere Act and the Goldamere Agreement have facilitated the re-opening of the Savage River mine and empowered Grange to operate and develop cost effective ARD and environmental management techniques. This in turn has enabled Grange to provide cost effective remediation of the Crown’s ARD legacy at Savage River.

The remediation program has led to the development of a trusting relationship between Grange and the Crown.

With the completion of the remediation program, including the planned South Deposit Tailings Dam, the key environmental risks associated with Savage River will be managed. Treatment of
approximately 90% of legacy acidity and associated copper loads will have been developed at minimal cost to the Crown.

Grange’s environmental record has enhanced its ability to grow and prosper. The introduction of equity partnerships and new business owners has been made significantly easier with potential environmental liabilities able to be described as assets to the business.

The operation of an ethical, sustainable operation is also providing opportunities to attract and recruit young professionals who are becoming scarce in a human resource constrained world.

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