STRATEGIC PLANNING FOR ARD REMEDIATION[1]

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Abstract. The Savage River Mine has operated as an open cut iron ore mine on the northwest coast of Tasmania since the mid 1960's. The impact from ARD became evident during the 1990's when monitoring found high levels of Cu and low pH in the river over 30 km downstream of the mine. Closure of the mine in the mid 1990's and subsequent reopening by new owners resulted in funding of approximately A$24M for remediation to be administered by a joint committee representing the mine owners and the Tasmanian state government.

Ecotoxicology work showed that Cu was not acutely toxic to aquatic life forms provided alkalinity levels of more than 15mg/L and pH>6.5 were maintained in the river. A feasibility study established methods of achieving these goals by a range of measures including oxygen exclusion covers, water shedding covers, ARD catch drains, pumping systems and use of centralized treatment facilities. The utilization of naturally occuring magnesite and other alkaline rocks was of particular interest. Capital and operating costs of possible options were estimated to +/- 30% for comparison then a whole of site strategic plan developed to demonstrate how the required level of remediation could be achieved and maintained over a 60-year time span using the funds available.

The Strategic Plan showed the committee that the aims of remediation were achievable and delivered a program that could be met by staged development making effective use of the operating mine resources.

The paper describes the site, the strategic plan and details of the implementation to date.

Additional Key Words: Savage River Mine, magnesite, acid drainage

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Introduction

The Savage River Iron Mine is located in northwest Tasmania at an elevation of 100–350 m in rugged and mountainous terrain covered with dense rainforest, approximately 300 km northwest of Hobart as shown in Fig. 1. The climate of the area is characterized by cool temperatures, and a high and consistent average annual rainfall of 1954 mm. Rainfall exceeds evaporation by a factor of about 2:1 (Bureau of Meteorology, 1996).

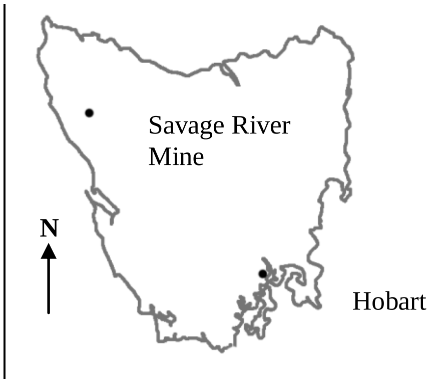

Figure 1 Locality Plan (Tasmania, Australia)

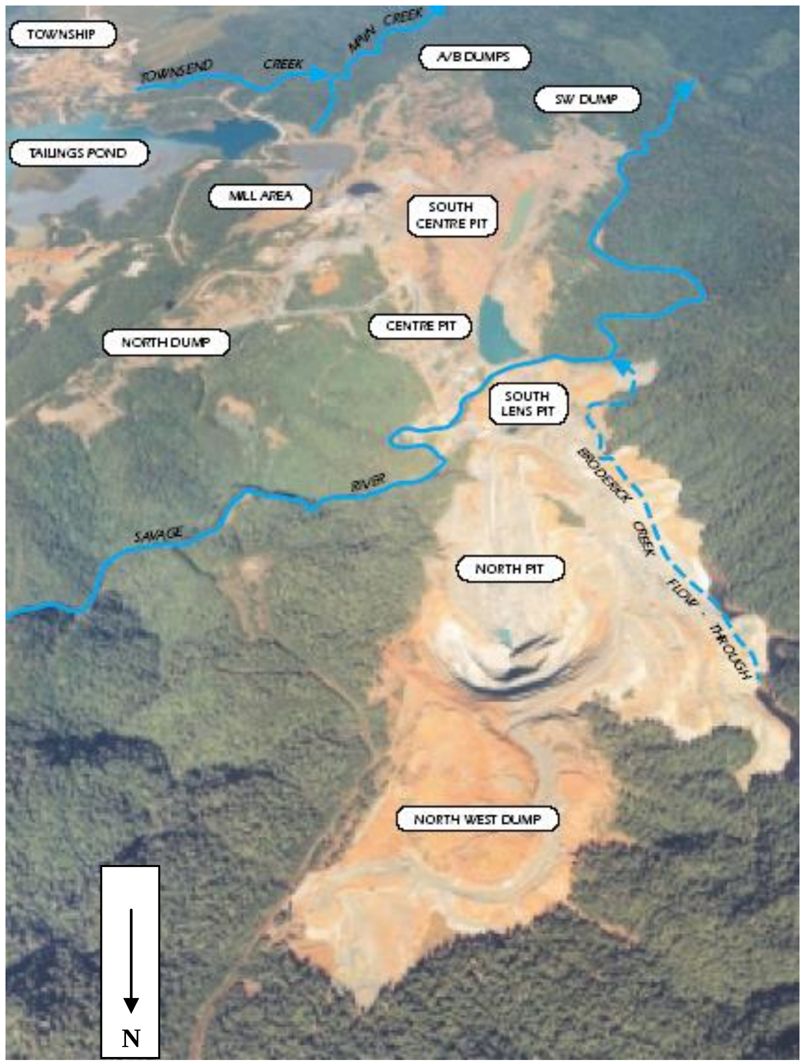

Figure 2 Aerial View of Savage River Mine

The Savage River iron deposit is located within a northeast striking narrow linear belt of Pre-Cambrian rocks. These have been metamorphosed to greenschist and amphibolite facies. Magnetite mineralization has been variously interpreted as being contemporaneous with the original rocks or, alternatively, representing a magnetite skarn associated with Devonian granitic intrusives. The host rocks of the Savage River deposit principally comprise serpentinites, volcanics and schists with lesser dolomites, magnesites and amphibolites. The ore zone and enclosing sequence strike north-south and dip near vertically. The main ore zone comprises massive and disseminated magnetite. The zone has a known strike length of 4km and reaches a thickness of 100-150m, but can occur as two or more thinner lenses. Down dip continuity is indicated to depths of up to 600m.

The mine was initially opened in 1967, operating several open cut pits along the north-south trending ore-body that crosses the Savage River. Major features of the site are shown in the aerial view of Fig. 2. The ore is concentrated at the mine site then transported as slurry in a pipeline 85km to Port Latta on the coast. At Port Latta the concentrate is pelletized prior to shipping to customers within Australia and internationally.

Operations over the first 30 years of mine life caused environmental harm to approximately 30km of the Savage River. Of the 30 km impacted, the reach downstream of the confluence with Main Creek exhibits the most severe degradation. This section was found in 1995 to have lost 90% of its invertebrate biodiversity and 99% of its invertebrate abundance (Kent et al, 2004). Savage River water quality reflected the influences of past mining, with suspended sediments and acid rock drainage containing elevated dissolved Cu, Al, Ni and Mn (Miedecke, 1996; Koehnken & Ray, 1999). Pit discharges, surface runoff, waste rock pile seeps, and tailings dam seeps and discharges all contributed to the deteriorating water quality. The high rainfall and low evaporation, in combination with steep topography, had resulted in erosion in disturbed areas, with increased sediment input evident in streams draining the area and in the Savage River itself. The Pieman River Monitoring Program data showed high metal concentrations in the Savage River (Koehnken, 1992) with the median copper concentration over 25 times the ANZECC (1992) recommended value for soft waters just below the mine site, 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 below the mine. The water quality in Main Creek, which received seeps from the tailings dam and several waste rock piles, was poor with a median pH of 4.5 and concentrations of Cu, Mn and Ni all well above the ANZECC (1992) and USEPA (1988) guideline values.

The ecosystem of the Savage River above the mine is also affected because the pollution prevents fish from migrating between the river and the sea, which is an essential part of the lifecycle of most Tasmanian native fish. Surveys show that the native fish fauna is severely depleted in the Savage River National Park, which is located above the mine (Kent et al, 2004)

The Savage River Rehabilitation Project (SRRP) commenced with the transfer of the Savage River Mine and Port Latta Pelletizing Plant from the former operator to the current operator Australian Bulk Minerals (ABM) in 1996, involving financial contribution from both the previous and current mine operators. Under the terms of the transfer ABM is indemnified from the effects of historical pollution at the mine site but is jointly responsible with the Tasmanian Department of Primary Industry, Water and Environment (DPIWE) to administer a A$24 million fund set up to finance the project to remediate the site.

The Rehabilitation Project Objectives

The Savage River Rehabilitation Project has clear objectives as summarized below:

- to promote recovery of a modified but healthy ecosystem in the Savage River downstream of the mine, and permit fish migration into the upper Savage River

- to develop and implement an agreed long-term strategic plan for the rehabilitation and remediation of historical disturbances at the Savage River Mine and Port Latta plant
- to integrate remediation works with ongoing mining operations wherever practical and to co-operate with ABM during the planning and implementation of projects
- to overtly demonstrate best practice in all aspects of the project and to communicate progress and findings to the community

Background to the Strategic Plan

During the first few years of the SRRP various studies were carried out to determine the sources of impact and to look at feasible remediation methods. The major sources and their contribution to site copper and acidity loads are shown in Table 1. Source areas are shown in Fig. 3.

Table 1 Contribution of Copper and Acidity Load from Various Site Catchments

Source	Cu Flux (kg/day) average	Cu Flux (kg/day) 95th Percentile	Average % Contribution Cu	Acidity Load (t/day) mean	Acidity Load (t/day) 95th Percentile
B Dump (Main Creek)	25	60	39.0%	1.2	3
SW Rock Dump			17.1%		
North Dump Drain	6.7	20	17.0%	0.33	0.87
Broderick Creek	3.7	9.4	6.8%	0.2	0.41
Crusher Gully	2.4	4.6	6.1%	0.11	0.19
Old Tailings Dam North	1.9	7.6	3.7%	0.28	1.2
Centre Pit Overflow	2.2	6.3	2.3%	0.031	0.098
Old Tailings Dam Seeps E	0.26	.52	0.0%	0.27	0.33
Old Tailings Dam Seeps W	0.15	0.33	0.0%	0.49	0.8
Old Tailings Dam Seeps missed (assume equal to surface collection)	0.41	0.85	0.00%	0.76	1.13
Total Main Creek, North Dump Drain, Crusher Gully, Old Tailings Dam North, North Dump North seep, OTD			67.50%	3.5	7.6

The studies determined that 65% of whole-of-site Cu emissions to the Savage River need to be removed to achieve toxicity targets (Kent, et al, 2004). This level of success can be achieved by treatment of discharges from four major sources where contaminated discharges can be collected. These comprise Main Creek below B-Dump, North Dump Drain, Crusher Gully and Old Tailings Dam.

A consultancy brief was developed by the SRRP committee to develop a strategy to achieve the required objectives using the funding available over an operating period of 60 years. This involved both technical and financial analysis of "whole of site" remediation options and determination of an appropriate strategy to achieve the project aims within the available funding constraints. The brief requires allowance for appropriate replacement of assets over the operating period and use of a discount rate of 3.5% for calculation of Net Present Value (NPV) and comparison of project options over total project life.

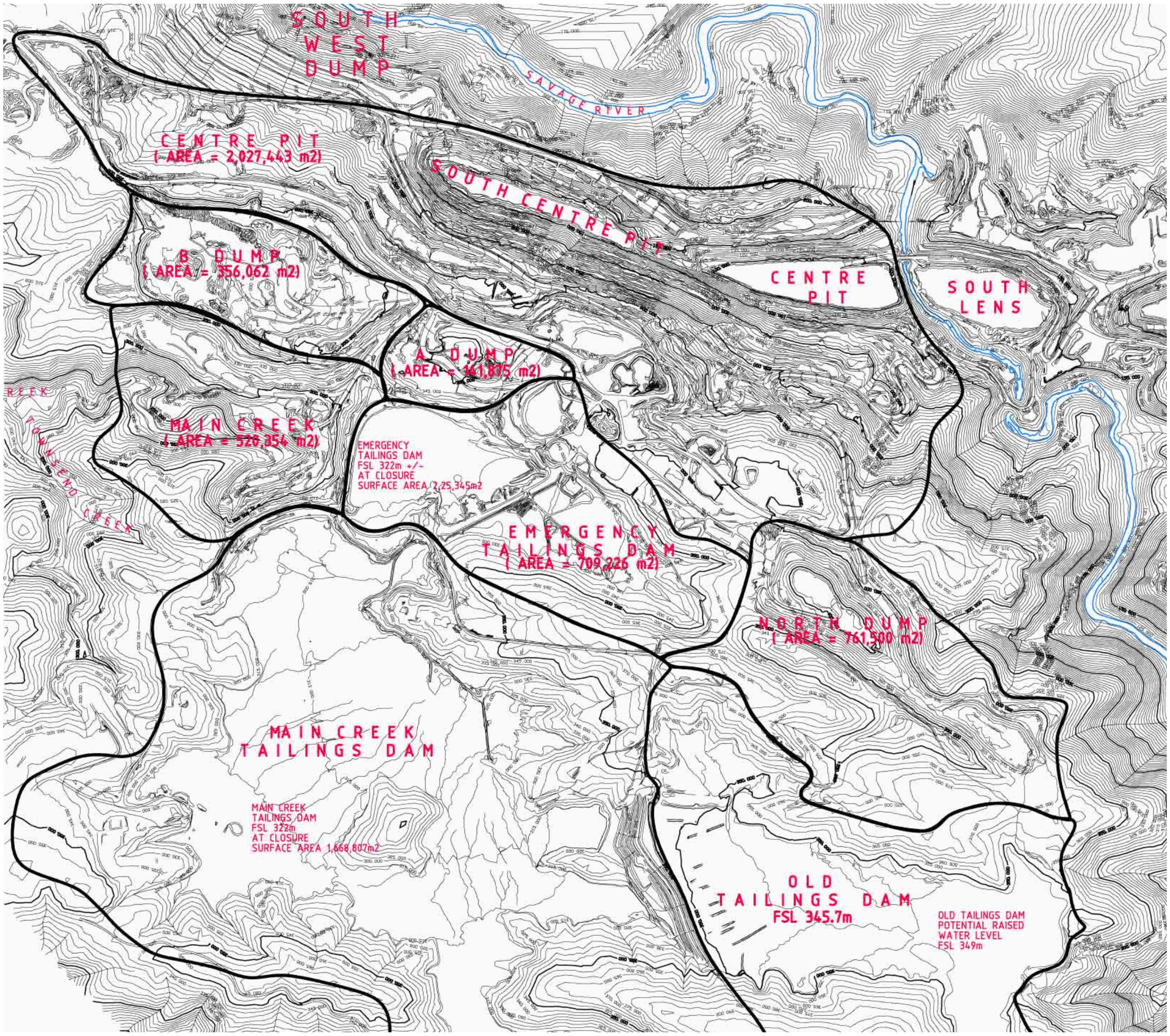

Figure 3 Catchment Areas for Stormwater Runoff at the Savage River Mine

Development of the Strategy

A variety of remediation systems were researched as part of the strategic plan development (Thompson and Brett Consulting Engineers, 2003). These included:

Passive Treatment Systems

System	Discussion
water covers	Some scope to at least partially flood tailings at Old Tailings Dam
high infiltration alkali covers	An emerging technology to introduce alkalinity to the top of dumps, but avoiding the problem of passivation by coating of alkali sources with precipitate. Potentially very expensive if not implemented as part of the mining operation.
oxygen barriers	Site climate aids the maintenance of saturated conditions in soil covers but oxidation of site rock piles is already advanced and dumps are likely to continue discharge of contaminated seepage for decades even if further oxidation is stopped.
water shedding covers	In Savage River climate, covers are unable to eliminate seepage but can be effective in reducing flows and thus influence cost of treatment. Monitoring of Main Creek above Townsend Creek, one of the major sources of Cu, clearly showed the impact of B-Dump on flow rates in the local catchment. During a period when operation of Main Creek Tailings Dam effectively removed Main Creek flow from the section of the creek below B-Dump the residual flow was surprisingly constant and represented approximately 70% of incident rainfall. The flow pattern suggested that the majority of rainwater was entering the dumps and disturbed ground and percolating through these to emerge as contaminated seepage over a period of months. Economic analyses confirmed that the costs of diversion of clean surface water from this area produced significant benefit in the overall cost of collection and pumping of contaminated water for treatment.
Alkali Flow Through Drain	The existing flow through spillway in Broderick Creek has proved to be a significant source of alkalinity.

Active Treatment Systems

Reagent	Discussion
magnesite	Available on site and possibly suitable as a reagent using an autogenous mill or purpose designed reactor
lime	High priced and low density sludge but proven technology
tailings	Potential use while ABM actively mining
bauxol	Expensive and unproven but potential for final polishing of effluent
calcium carbonate schist	On site material but limited scope for pH increase

The review of options found that unless ABM could incorporate passive systems into their mining operations then it was uneconomical to develop a completely passive remediation plan. Furthermore capping was unlikely to reduce total contaminant loads but could affect the cost of water management in collecting and pumping systems. Treatment of some form was essential.

A variety of options were subject to preliminary design to develop cost estimates to ± 30%. These estimates included consideration of operating and maintenance costs over a 60 year period and resulted in assessment of Net Present Value (NPV) estimates for each option. This allowed a direct comparison to rank options in order of their long term economic viability.

Active treatment in conjunction with clean flow diversion was identified as the priority with the selection of method depending on the efficiency of reagent use. A key factor to the feasibility of active treatment was ABM's decision to close the open cut mine operation in 5 years, thus leaving one or more of the open cut pits available for sludge disposal. This is particularly significant due to the very voluminous nature of treated AD sludge from simple treatment processes. The pit selected for sludge disposal is naturally alkaline giving confidence that the precipitated sludge will continue to be stable into the long term. A significant concern with free stream discharge of sludge is that metals could be remobilized in the future, particularly given the natural low pH of the natural streams of the area.

A milling process using magnesite proved to be the most promising option provided the treatment efficiency could be maintained at around 60%. This appeared feasible by utilizing direct contact in the mill and by utilizing post-treatment contact in the discharge water in site drains and ultimately in the open pit. Field trials are proposed to confirm this. If the magnesite mill system proves not to be efficient enough then additional conventional lime treatment will be required.

The Strategic Plan

The proposed components of the "whole of site" rehabilitation plan is presented in Fig. 4.

This comprises

- A centralized autogenous mill treatment plant (subject to efficiency testing) located near the ABM security gate entry area, discharging treated water to Centre pit via a series of turbulent channels and settlement ponds.
- Collection of "concentrated" AD from Main Creek and Old Tailings Dam sites and pumping to the treatment plant. AD will be "concentrated" by maximizing clean water diversion from the sources of contamination.
- Diversion of North Dump drainage via a pipeline to a mixing pond above Centre Pit where it will be mixed with alkaline water from the mill plant before entering Centre Pit.
- Diversion of the eastern catchment of North Dump Drain to the OTD.
- Diversion of maximum clean water through the Main Creek and Emergency Tailings Dams to a mini-hydro power station in the Savage River below South West Dump.

The total NPV of the work items noted is estimated in the order of AUD$13M. This does not take into account costs of capping and flow diversion undertaken by ABM as part of their contributions to the strategy through mining operations.

Of particular interest, in conjunction with the rehabilitation project, was the feasibility of providing a 0.75 mW mini-hydro power scheme. This has an NPV of approximately AUD$2.4M but is potentially an income producing asset that would help fund the ongoing remediation as well as providing a source of power for the pumping and treatment operations.

The scheme allows for collection of surface water from the clean water diversions over the site. The water would be stored in the Main Creek Tailings Dam and released via a penstock to the Savage River below South-West Dump, a total drop of approximately 230m.

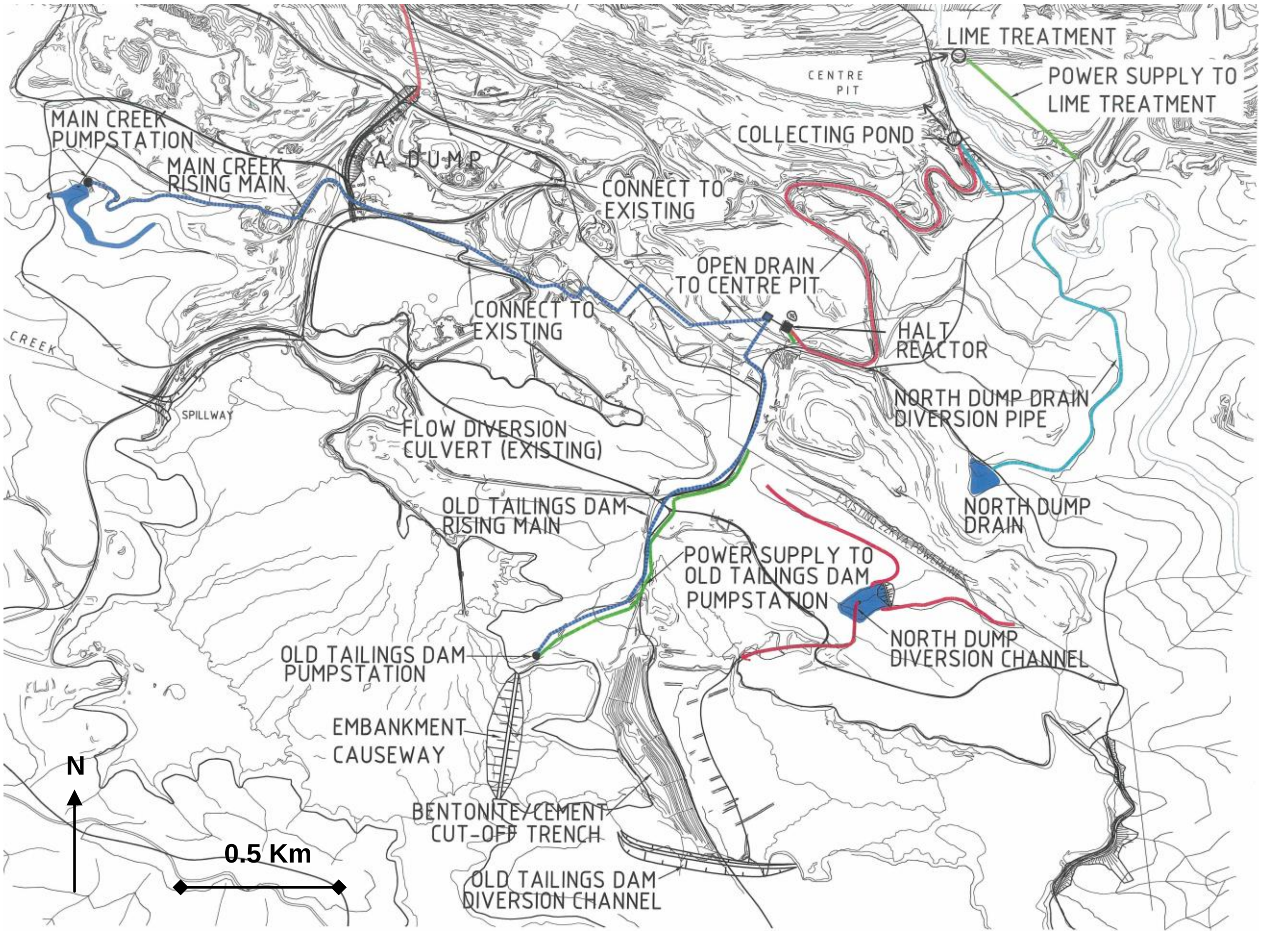

Figure 4 Overall site concepts for "clean" water diversion, acid drainage collection and distribution to treatment facilities

Conclusion

The Savage River Remediation Plan allows a partnership between government and the mining company to develop and implement effective remediation options with the limited funds available.

The strategic plan has received support from Government and Industry as it provides both flexibility and direction while achieving the project objectives. As a direct consequence of this unique regulatory solution, in the past 5 years, the Savage River has gone from one that was significantly impacted by acid rock drainage for 30 kilometers downstream, to one where trout now travel through the reaches of the mining lease. Real solutions are now feasible both economically and practically.

The arrangements between ABM and the Tasmanian Government are an example of a genuine WIN WIN situation where co-operative environmental management of the site results in significant improvements and where the ‘regulator’ and the ‘polluter’ are working together to achieve mutually beneficial goals. The end result is a significant benefit to Tasmania.

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