The beginning

Just imagine the following scenario: a new company takes over a large, historically degraded mine.

The Government accepts responsibility for the historical environmental problems at the mine and the incoming company takes responsibility for environmental management of its own operations.

However, the new operator’s activities will affect almost the entire historical mine site.

The new operator must commit substantial capital sums to redevelop the mine at a time when revenues are low.

At the same time the agreement by which the company purchased the mine requires the company to fund remediation activities co-ordinated by the Government, and to pay interest to the Government on the outstanding mine purchase price.

It should be apparent that there is potential for differences of opinion and tension, perhaps even for litigation under this scenario.

But this is the Savage River Rehabilitation Project (SRRP) scenario.

During 1999, the parties - the Tasmanian Government and Australian Bulk Minerals, a subsidiary of Ivanhoe Mines Limited (ABM) - completely renegotiated that agreement.

One important result of the negotiations was the formation of the SRRP Management Committee, made up of both government and company representatives.

Through the committee, the Government and the company now jointly oversee SRRP activities.
Savage River Mine

The Savage River Mine is located in Northwest Tasmania at an elevation of 100-350 metres.

The terrain is rugged and mountainous, and covered with dense rain forest.

The mine and concentrating plant are both in the Savage River valley, with the Savage River flowing through the mine site and ultimately discharging into the Pieman River, which then flows westward to the coast.

The climate of the area is characterised by cool temperatures, and high and consistent annual rainfall (average 1900mm).

The Savage River Mine was established in 1967 to develop an open cut iron ore mine, concentrator and township at Savage River and an 83km concentrate pipeline to a pelletising plant at Port Latta.

The mine was operated as a conventional open cut with pits south and north of Savage River.

Waste and ore production continued until April 1996, when all mining ceased for a short period while the Government sought a new operator for the mine.

Mining activities at Savage River had a detrimental effect on water quality downstream of the site.

Until cessation of active mining, pit water was pumped from the pits into the Savage River.

Rainfall entering waste rock dumps dissolves chemicals (particularly copper), which are formed in the dumps when certain rock types (sulfides) react with oxygen in the atmosphere after they have been excavated from the mine pits.

When this contaminated water later leaks out of the dumps it is referred to as acid drainage (AD). AD can produce elevated heavy metal levels downstream of the mine.

The high rainfall and low evaporation in combination with steep topography resulted in increased erosion in disturbed areas, with increased sediment input over the last 30 years being evident in streams draining the area and in the Savage River itself.

Under the agreement with the new operator, ABM, the Government has given the company an indemnity in relation to historical pollution.

AD from the previous operation may continue in the long term.

With heavy machinery and capable staff present on site, ABM is uniquely placed to perform certain remediation works on behalf of the Government.

Funds for the remediation are provided by ABM’s purchase price and by remediation funds left by the former owners, Pickands Mather & Co. Incorporated (PMI).

The purchase price agreement allows for ABM to undertake remediation contracts for the Government to "work off" the purchase price owed by ABM.

Together, ABM and the Government through the Department of Primary Industries, Water and Environment (DPIWE) will co-operatively manage...
the remediation process in conjunction with ABM’s mining operation to maximise benefits for both parties.

These benefits include:

- Maximising cost effective remediation of past pollution;
- Sharing knowledge regarding remediation;
- Increasing knowledge of both DPIWE and ABM regarding remediation of AD and pollution from old mining operations.

By demonstrating that a mining company and DPIWE can work together to co-operatively manage a project such as SRRP, the Government is establishing benchmarks which other communities should follow.

What state is the Savage River in?

By Dr Peter Davies, Freshwater Systems

DPWE commissioned surveys of fish and macroinvertebrates (mainly aquatic insects and crustaceans) in 1997/98, and those results were compared with a similar survey of macroinvertebrates conducted in 1995.

The Savage River upstream of the mine is in a near-pristine condition, with a diverse and abundant macroinvertebrate community.

Downstream of the mine, the river is in a very poor condition, particularly downstream of Main Creek, the tributary experiencing the greatest metal concentrations.

Fish and macroinvertebrates are present in the lower reaches of Savage River, but at significantly lower densities than in similar reaches in nearby unpolluted rivers.

The 1995 study found that up to 90% of the major taxa (families) of aquatic macroinvertebrates and up to 99% of the macroinvertebrate abundance had been eliminated in some sections of the Savage River.

Nonetheless some native fish species occasionally migrate through the most polluted reach of Savage River.

No macroinvertebrates or fish were found in Main Creek.

Limited recovery was evident in the two most downstream study sites with an increase in diversity of macroinvertebrates between 1995 and 1997/98.

However, these sites were still 40-60% less diverse than unpolluted sites, and sites between the mine and Main Creek (7km of river) were slightly more impacted in 1998 than in 1995.

In 1997/98 the total macroinvertebrate abundance for sites downstream of the mine was 80% less than that of upstream Savage River and other control sites.

What needs to be done?

The above field studies did not investigate whether the observed ecological degradation was caused primarily by AD or by a combination of factors including sedimentation, among others.

Toxicological testing was therefore undertaken during 2000 at laboratories in Queenstown and Hobart.

Tests were conducted using various mixtures of water prepared from raw AD from the Savage River Mine, unpolluted West Coast river water, and AD neutralised using limestone and magnesite.

Tests were conducted with two species of fish - rainbow trout and native mountain trout plus two species of aquatic insect, and one species of freshwater algae.

Fish growth and respiration rates as well as algal population growth rates were measured.

Comparison of the test results showed that Savage River AD is highly toxic where the downstream environment is low in alkalinity and pH, however, when the pH of the river is greater than 6 and alkalinity, calcium and magnesium concentrations are greater than 15 parts per million (ppm) the toxicity of the AD is not acute.

These conditions are known to occur for more than 90% of the time based on recent data from the Savage River.

Restoration of the downstream environment therefore requires that the respective pH and alkalinity targets of 6 and 15 be achieved as close as possible to 100% of the time.

Environmental target levels for certain heavy metals were also recommended as part of this study.

Checking water quality

During the past three years DPIWE has carried out an intensive water quality audit on the Savage River Mine Lease.

This has allowed the Government to prioritise areas of the mine for rehabilitation.

This process has required the monitoring of 15 significant sources of AD around the site.

All monitoring has been carried out with measurements of flow as well as chemical parameters.

This has allowed the mass load of pollutants to be compared between the various sources.

A set of graphs illustrating a pollution audit for a particular part of the mine is illustrated on the next page.
developed by DPIWE ("Splash-Back") is given to the mine and consultants working on the mine. Similarly data collected by ABM is shared with the Government.

The programs have simplified report writing and general data analysis substantially.

The other real advantage of the software is that it has made independent analysis of the data simple.

This means the findings of the Government can be easily checked and reviewed.

It has also allowed ABM to use the data for their own environmental needs.

**Works to date**

Remediation works so far include the removal and burial of infrastructure (such as road surfaces and building foundations) within the former township. This has made the revegetation of those areas possible (see photos opposite).

DPIWE has contracted ABM to construct a compacted clay cover above part of the historical South West Dump to reduce the infiltration of rainfall and also to excavate the historical North West Dump and place it in encapsulated dumps constructed to best practice environmental standards.

The Government has also appointed ABM to undertake various monitoring works around the site and to maintain alkalinity in the outflow from ABM’s tailings dam (which receives acid discharges from a historical tailings dam).

**Preventing further damage**

Since commencing operations in 1997, ABM has, as part of its environmental management policy, significantly improved the handling of surface runoff from its mining operations and from old waste dump seeps.

Historically, surface runoff and mine-dewatering flows had essentially been directed straight into the river system.

ABM initially directed the various runoff streams into roadside settling ponds before discharge into the river, but the volumes during large rainfall events occasionally caused problems with settlement times.

In the past two years the majority of runoff and pumped pit waters has been directed into unused pits to allow an enhanced settlement time and for pH treatment.

During 1998/99 the majority of ABM’s mining activities were based north of the Savage River.

Centre Pit, which is south of the river, was used...
as a settling pond for pit waters being pumped out of the South Lens and North Pits (refer to aerial view on page 7).

Water naturally flowing from magnesite deposits adjacent to both of the northern pits tends to be alkaline in nature.

Water that was pumped from these pits therefore assisted in treating the Centre Pit waters, which were at times acidic.

In 1999, mining was completed in South Lens and the pit was allowed to flood.

In late 1999, ABM commenced operations on the west side of Centre Pit, which has required dewatering of the Centre Pit lake during the past year.

Centre Pit also has a reported alkaline inflow component, presumably from another magnesite deposit just south of the river on the east side.

Unfortunately there are also several inflows of an acidic nature.

South Centre Pit has at times very acidic waters (pH ~3) which DPIWE treats by the addition of lime.

To the east of Centre Pit there is an historic waste dump, referred to as the Crusher Gully Dump, which produces AD.

Part of this flow probably seeps through the fractured eastern wall rocks or enters from depressurisation drains previously drilled into the wall and under the dump.

An additional source of acidic water is the surface runoff from other dumps further to the east of Centre Pit.

Most of this water is surface runoff that makes its way down the main mine access road, located for the most part on top of the Crusher Gully Dump.

Throughout 1997-1999, ABM and DPIWE have monitored and managed the water overflow quality from Centre Pit.
With the commencement of mining and dewatering of Centre Pit all of the water was directed into the alkaline rich South Lens pit.

This pit, which is approximately 300m long, 100m wide and 60m deep, provides adequate settlement time.

Surface runoff down the mine access road is conveyed from a small catchment dam direct to South Lens via a 250mm diameter gravity fed poly-pipeline.

Throughout most of 2000 all the other Centre Pit water was pumped directly into South Lens.

More recently, as the pit developed, DPIWE funded another 250mm diameter poly-pipe from South Centre Pit along the western wall of Centre Pit.

This gravity feeds the South Centre Pit overflow directly into the large South Lens settlement pond.

Future ABM operations will develop a new “South Deposit” pit, as the name implies to the south of existing operations.

The intent is to pump the mine waters by a new pipeline and an open ditch to South Centre Pit and to then use the existing gravity feed pipeline to transfer the water to South Lens.

The advantage of providing a centralised water settlement and holding facility is the ability to monitor and treat water if necessary at a single location to ensure that ambient values are not adversely impacted.

Another major benefit is the neutralising effect of naturally alkaline groundwater that enters the pit.

Current indications are positive with noted improvements in both water quality and anecdotal reports of the return of fish species to the mine’s precinct.

Various other projects have also been undertaken by ABM to intercept surface seepage from historic dumps and to direct these into treatment ponds.

ABM and DPIWE work closely to manage water quality from both ABM’s mining operations (ABM’s responsibility) and from the historic dump seeps (DPIWE’s responsibility).

Taking some acid out

Open pit mining, such as that carried out by ABM, results in large amounts of waste rock.

This waste must be disposed of in not only an economical manner but also in a way to prevent the generation of AD.

In the past decade, prior to ABM’s operation, much of the waste from North Pit was disposed of in hillside dumps along the eastern side of Broderick Creek.

In places these dumps encroached on the creek itself.

On leaving the site the previous operators placed some clay on the rock dump slopes to assist in the re-vegetation process.

Hillside dumps in steep terrain can be inefficient; as only relatively small amounts of rock waste can be placed on a hillside and still ensure long term stability of the slopes.

To overcome the waste volume and slope stability problems ABM’s consultant, Thompson and Brett Pty Ltd, proposed that a coarse rock flow-through structure be constructed in the base of Broderick Creek.

South Lens settling basin (note size of Toyota Hilux at centre right)
The intent of the flow-through is just that; i.e. water is to flow through the dump relatively unimpeded.

To prevent the generation of AD only coarse non-acid forming (NAF) rock was to be utilized in the construction of the flow-through.

The coarse rock was in turn to be encapsulated by a clay cover.

The above sketch indicates how a thick layer of uncompacted clay was first tipped off the original hillside dump.

This was followed by the tipping of coarse NAF rock across the creek bed and far side hill for a width of 40 metres.

By tipping from approximately 20 metres in height a highly permeable base was formed, which only slightly impedes the flow of water.

Once the flow through was completed it was covered with compacted clay.

Potentially acid forming (PAF) waste rock is now being placed all the way across the Broderick Creek valley (as can be seen in the aerial view) and it in turn is being encapsulated with clay.

The clay encapsulation is in line with the current World’s Best Practice for the disposal of potential acid forming waste rock.

An added environmental benefit of this flow-through construction was the use by ABM of acid consuming carbonate chlorite schist as the NAF coarse rock material.

Monitoring of the water quality of the creek has shown a marked increase in alkalinity, from 19 ppm in 1997 prior to the construction, compared to 39, 53 and 55 ppm in 1998 to 2000 respectively (based on July readings).

Toxicity testing (see “What needs to be done?”, page 3) has indicated that increased alkalinity levels of > 15 ppm and a pH of > 6.0 will be required in the Savage River for restoration of ecosystem health.

The addition of alkalinity from the Broderick Creek flow-through will assist in that endeavour.

**Future directions**

by David Brett, Thompson & Brett Consulting Engineers

Tasmanian based consulting engineers Thompson & Brett Pty Ltd has been involved in several SRRP projects aimed at evaluating the technical and economic benefits of clay capping waste rock dumps at the Savage River site.

In the wet environment of the West Coast, runoff of rainfall from the natural environment averages around 75% of the 1900mm annual rainfall.

During wetter months this can increase to in excess of 90%. On the other hand, testing has shown that runoff from waste rock dumps comprising very permeable rock fill is negligible.

Reducing the flow of water into the dumps may not reduce the total mass loading of contaminants leaking out (if the concentration of pollutants simply increases) but it can have a significant impact on the cost of treatment simply due to the reduced cost of dams, pumps and pipelines required to collect, transport and handle the flow.

As part of the Hairpin Dump study, Thompson & Brett has...
modelled dump performance using the software program SoilCover, developed by the University of Saskatchewan in Canada.

This program estimates water flow in unsaturated soils.

The modelling suggested that:

- for no cover, all rainfall would be intercepted by the dump and apart from around 12% lost by surface evaporation, it would all seep out of the dump base some two to three months later;
- for poor quality capping, a small proportion of rainfall during heavy storm events would be shed but overall seepage would be similar to the “no cover” case; and
- where a good quality clay cap using low permeability clay (i.e. permeability of around $10^{-8}$ m/sec) was modelled, results suggested that runoff would increase substantially with seepage reduced to around 10% of the no cap case.

The modelling also implied that even the poor quality clay cap would maintain in excess of 85% water saturation even during a simulated record drought.

The possibility therefore exists that a clay cover at Savage River could also act as a barrier to oxygen entering the dump (because at greater than 85% saturation water effectively blocks the very small pore spaces in the clay).

Exclusion of oxygen may significantly reduce the rate of formation of AD within a rock dump, though this may have the side effect of greatly extending the ‘pollution life’ of the dump which may in turn be a disadvantage where treatment of acid is being undertaken.

Irrespective of the potential benefits of reduced oxygen entry, it has been estimated that cost savings of millions of dollars could be realised by capping historical dumps, due to reduced infrastructure costs and capitalised running costs including power and maintenance over a conceptual 50 year period of water treatment.

The potential reduction in total flow rate of AD to be treated may also allow the implementation of cost saving treatment options that would otherwise be impractical.

These include potential use of ABM tailings material as a neutralising agent and disposal of resulting sludge in ABM’s Main Creek Tailings Dam.

These options are currently under detailed investigation.

The following consultants have contributed to SRRP works and investigations under contract to DPIWE:

- **Australian Nuclear Science & Technology Organisation**
- **Cape Country Gravel (Neville Harper)**
- **Caradale Landscaping & Excavating**
- **Coffey Geosciences Pty Ltd**
- **David Mitchell Tasmania**
- **Dobos & Associates Pty Ltd**
- **Earth Systems Pty Ltd**
- **Freshwater Systems (P.E. & L.M. Davies Pty Ltd) - see article on page 3**
- **HydroTasmania (Hydro-Electric Corporation)**
- **Joe Fagan Heavy Haulage Pty Ltd**
- **John Miedecke & Partners Pty Ltd**
- **Land Management & Rehabilitation Services Pty Ltd**
- **McKenzie Contracting Pty Ltd**
- **North West Land Managers (G.J. Taylor & J.I. Morse)**
- **Oil Spill Cleanup Co. Pty Ltd**
- **Pitt & Sherry Holdings Pty Ltd**
- **SEMF holdings Pty Ltd**
- **Technical Advice on Water (Dr Lois Koehnken)**
- **Thompson & Brett Pty Ltd - see article on page 7**
- **West Coast Transport Pty Ltd**

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